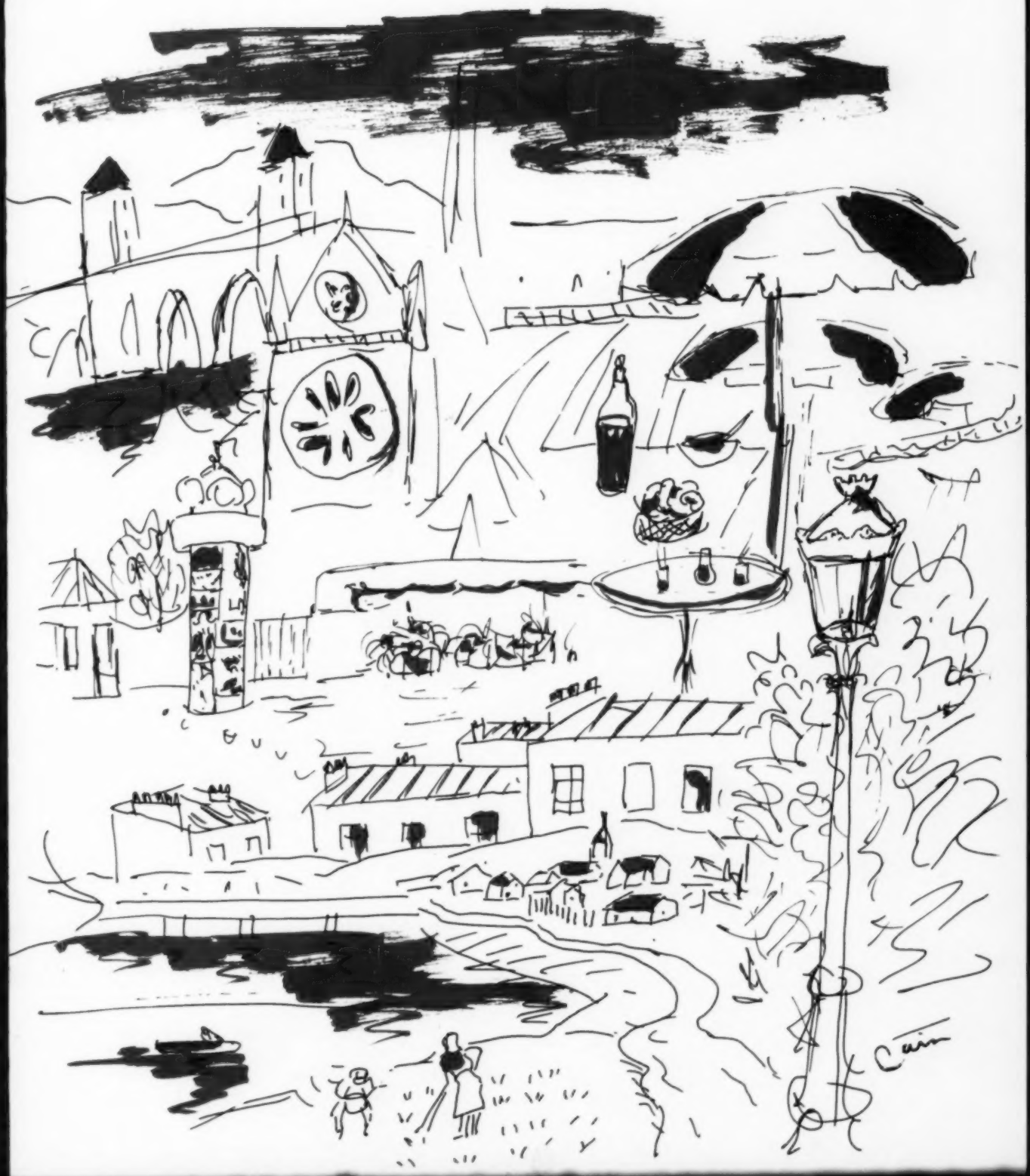
JOURNAL OF

METALS

JUNE 1961



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JOURNAL OF

METALS

Vol. 13, No. 6
June, 1961

COVER: "Paris in the Spring, tra-la" . . . Metallurgy in France, ta, ta . . . Especially IRSID, la-bas. And with spring, young mens' fancies turn to page 411 to learn something about the activities of the French ferrous metallurgical research institute, IRSID. Our cover is by David Cain.

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personnel

• These items are listings of the Engineering Societies Personnel Service, Inc. This Service, which cooperates with the societies of Civil, Electrical, Chemical Mechanical, Mining, Metallurgical, and Petroleum Engineers, is available to all engineers, members and non-members, and is operated on a nonprofit basis. If you are interested in any of these listings, and are not registered, you may apply by letter or resume and mail to the office nearest your place of residence, with the understanding that should you secure a position as a result of these listings you will pay the regular employment fee of 60% of the first month's salary if a non-member, 50% if a member. Also, that you will agree to sign our placement fee arrangement which will be mailed to you immediately after receiving your application. In sending applications be sure to list the key and job number.

• When making application for a position, include eight cents in stamps for forwarding application to the employer and for returning, when possible.

—MEN AVAILABLE—

Heat Treating Superintendent or Engineer, BME (Metallurgical option). Eight years experience purchasing, installation, and operation of high volume ferrous manufacturing heat treat including annealing, controlled carburizing, hardening, press quenching and personnel supervision. Prefer East or South. M-253.

Mature Physical Ferrous Metallurgist, solid accomplishments, radically new research on alloy development, hardening mechanisms, deformation studies; market research, sales planning and promotion, administration. Graduate, employed, will relocate, age 53. Available July. M-254.

Process Metallurgist (non-ferrous, lead, silver, copper, gold, zinc), age 41, married, one child, BSc Guebingen University, Germany. Four years experience smelter chemist, Peru; four years experience process metallurgist, Burma. Fluent English and Spanish. Prefer South America. Presently located in Germany, M-255.

Consultant, MetE, AIME, age 70. Twenty years experience in private commercial production nonferrous hi-purity ingot metals USA and foreign countries. Twenty-five years research and development extractive process metallurgy. Prefer Southwest US. Home: Nevada. $400. Se-1241.

Research Development Engineer, MetE, AIME, age 24. Recent graduate with some experience in drafting and designing in silver, lead, copper plants. Prefer West US. Home: Canada. $7,000. Se-1379.

Metallurgist, MetE, AIME, age 38. Two years experience in melting procedures, laboratory operation, sand control, advisor on welding and other technical problems on iron and steel. Two years experience in metallurgy and brazing on research program for brazed titanium honeycomb panels, consultant on ferrous castings regarding their specification, procurement, heat treatment, usage. Two years in charge of experimental stress analysis lab, supervised all metallurgical aspects of making, heat treating, matching and testing of experimental casting. Prefer West US or Foreign. Home: Illinois. $13,000. Se-1483.

Metallurgist, MetE, AIME, age 27. Eighteen months metallurgical chemist in zinc plant, including production, quality control, lab work. Prefer Western US. Home: Idaho. $7,000. Se-1651.

—POSITIONS OPEN—

Teaching Position, Physical Metallurgist, with teaching and industrial experience. PhD degree essential, also recognized research publications. Will teach undergraduate and graduate students and direct graduate student research. Salary and rank commensurate with experience and proven ability. Available September 1961. East. W272.

Metallurgical Engineers who have specialized in selling hard surfacing materials to the welding industry. Traveling and relocation will be involved. $10,000 year. Headquarters, New York City. W252.

Junior Metallurgists for ore dressing, either recent graduates of with a few years experience for investigation in processes in magnetic, gravity and flotation for recovery of ilmenite in a 7000 tpd concentrator. Salary commensurate with experience. East. W258.

Research Assistantship in Process Metallurgy Research. Salary, approximately $3600 year for BS degree holders in metallurgical engineering or physical chemistry. Arrangements permit full time experimental and course work toward MS or PhD. Available June 1961. Eastern university. W217.

Sales Engineer with mechanical or metallurgical engineering education and metal products sales experience, to sell metal working and processing equipment. $6000-$8000 year plus bonus. Midwest. W181.

Plant Manager, Welding, degree in chemistry, metallurgy or mechanical, to supervise production of electrodes, rods, fluxes and allied products. Must have experience in manufacturing with emphasis on scheduling, inventory control, plant layout, quality control, an awareness of costs and skill in personnel relations. $12,000-$15,000 year plus fringe benefits, profit sharing. New York, N.Y. W161.

Spectrographer, BS, preferably in metallurgy. Should have experience in emission spectrography. Will have to establish standard for routine analysis of copper, gold, similar and related by-products. Salary open. New Jersey. W151.

Engineers, (a) Plant Superintendent, nonferrous metals and alloys, experienced in industrial relations, materials handling and familiar with furnace operation, gas and electric. Must be cost conscious. (b) Plant Metallurgist, non-ferrous metals and alloys, for modern chemical and spectrographic laboratory; new product development; practical research work; to improve present processes. (c) Purchasing assistant, non-ferrous metals, secondary and fabricated. Technical and metallurgical background helpful. Salaries open. New York Metropolitan area. W126.

Pyrometallurgical Extractive Metallurgist, degree, 30-40, for research and development work and perferably with electric furnace experience. $8500-$9500 year. New York State. W124.

Research Assistanceship graduate program leading to PhD in physical metallurgy. Emphasis on phase equilibria, crystal imperfections, plastic deformation in alloys, ceramics and intermetallics. Full-time summer research employment, half-time during academic year. Stipend $3800 to $4400 for 12 months plus tuition remission. Colorado. C8606.

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Mill Man, $700, housing available, in Mountain states, milling background, age open. Well experienced in five hundred tpd operation. Able to handle all mill operations and supervise crews, and take care of his own metallurgy in a flotation process. For an operating property. Sj-5939.

Research Metallurgist, preferably with advanced degree, for work on physical metallurgy and metals research for independent research organization in Rocky Mountain area. Should be able to originate, organize and supervise research projects in this field. Salary open, dependent upon background. W316.

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A weekly bulletin of engineering positions open is available to AIME members at a subscription rate of $4.50 per quarter or $14 per annum; $4.50 per quarter or $14 per annum for nonmembers, payable in advance. Local offices of the Personnel Service are at 8 W. 40th St., New York 18; 57 Post St., San Francisco; and 29 E. Madison St., Chicago 1.

METALGRAMS

UNION CARBIDE METALS

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JUNE 1961

NEW ECONOMIES IN MAKING STAINLESS -- New oxygen-blown refined chrome allows savings three ways: (1) The alloy has a lower price due to economies in oxygen blowing ferrochrome. (2) Reduced carbon and silicon contents allow greater use of this low-cost chromium in the charge. By using more refined chrome in the charge, less chromium as low-carbon ferrochrome is needed later in the heat. (3) Less lime is needed to neutralize silica formed during decarburization. (The lower silicon content of the alloy forms less silica.) For more information, call your UCM representative or write for "Even Alloys are Oxygen Blown" in the Summer 1961 issue of UNION CARBIDE METALS REVIEW.

* * *

BAGS BOOST YIELD, CUT COSTS -- Tight control of silicon used for ladle deoxidation of open-hearth heats gives improved ingot structures. As a result, fewer rejections are obtained in the finishing mill and mill yields are improved. Bagged 50 per cent ferrosilicon provides closer control over deoxidation than loose alloys. The bags give higher and more uniform silicon recoveries. They also give better control of semi-killed ingot structures, improving the surface of plates and reducing rejections caused by over-deoxidation (pipe). One producer improved mill yield by 1.5 per cent and saved about $0.60 per ton. For more information, write for F-20,121 and F-20,128.

* * *

TOP BLOCKING PERFORMANCE FOR OPEN-HEARTHS -- Silicomanganese blocks meet the needs of today's fast-moving open-hearths. The fast-dissolving alloy reduces blocking time and allows better control of carbon content and alloy additions. Thus, you get lower alloy costs and fewer off-grade heats. Silicomanganese blocks also produce cleaner steel by reducing undesirable oxides. Mechanical and fatigue properties are therefore improved. Get facts and figures in a new 12-page booklet, F-20,166. Included are graphs showing production results.

* * *

VANADIUM...PUTS MUSCLE IN STEEL -- An important alloying element in tool steels, vanadium produces stronger, tougher tools that hold their cutting edge. Up to 5 per cent vanadium is used in high-speed tool steels to improve wear resistance and red hardness. In engineering steels, 0.10 to 0.25 per cent vanadium boosts strength and fatigue resistance. Vanadium also improves the high-temperature creep resistance of steam- and gas-turbine ferrous-base parts. For such additions, Union Carbide Metals offers ferrovanadium, vanadium oxide, and self-reducing vanadium. Contact your UCM representative for more information. Also, ask for the article, "The Elements That Surround Us: Vanadium," in the Summer 1960 issue of UNION CARBIDE METALS REVIEW.

* * *

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AROUND THE SECTIONS

Better Refractories Meet The Challenge Hicks Tells Western Section, NOHC

The trend toward higher purity basic refractories is a response to the demand of the steel industry for greater production from present steelmaking facilities, James C. Hicks, director of research for Kaiser Refractories & Chemicals div. of Kaiser Aluminum & Chemical Corp., told the Western section, NOHC, at a recent meeting in Los Angeles.

Mr. Hicks described the progress in steel production rates as spectacular, saying that when he first "appeared on the scene of the crime, many open-hearth steel shops seemed to be quite content with a production rate of 14 tph, tap to tap, and those shops which were achieving 20 tph were looked at with respect. Today several shops are regularly hitting rates of 45 tph, and we are beginning to hear tales of open-hearth production rates as high as 100 tph."

Mr. Hicks described what modified steelmaking practices and tremendously increased production rates may be doing to refractories and what producers are doing to produce better refractories. "The very fact that the reactions involved in steelmaking and slag making are progressing more rapidly implies that the destructive reactions on the refractories are also proceeding at greatly accelerated rates," Mr. Hicks stated.

He continued, "A further consequence of the use of oxygen in steelmaking is the effect upon the furnace atmospheres. . . . In the case of the LD process, CO concentrations up to 85 or 90 pct have been measured in the exit gases. The very vigorous reaction from the use of oxygen in the bath also produces copious quantities of iron oxide fumes which are carried to the working face of the refractory lining. This combination of high temperature, strongly reducing atmosphere, and ferrous oxide constitutes an extremely difficult challenge to the refractory producer."

Basic open-hearth roof bricks have been one of the major problem areas in achieving operating economy at high production rates.

"One of the first steps taken by producers in improving basic refractories," Mr. Hicks said, "was the modification of the silicate phase to make it more refractory. This was done by adding more magnesia. Later synthetic magnesia, largely periclase, crystalline MgO, became available. These were lower in fluxing impurities, particularly lime, than the natural product, and yielded increased refractoriness in the brick.

"The recently greatly increased use of oxygen has focused attention upon the higher purity materials," Mr. Hicks declared, "and the present trend is toward the utilization of periclase analyzing substantially under 2 pct in both silica and lime for the more severe service locations, such as for open-hearth roofs. At the present time, all of the magnesia producers in this country are in a position to offer at least experimental quantities of the high-purity, two-stage, fired periclase."

"In seeking improved refractory performance, two areas are currently receiving greater attention; these are the study of the high temperature strength of the refractory and the effect of reducing atmospheres," Mr. Hicks said. ". . . research laboratories have made considerable progress in studying the modulus of rupture of bricks, measured at temperatures as high as 2500°F. One of the difficulties in going to a higher purity refractory has been the reduction in the hot modulus which occurred at temperatures in the neighborhood of 1500°F as a result of the reduction in the matrix phase. However, with the proper compounding of the bond portion, and with particular attention to the method of fabrication to give optimum density and uniformity, the hot modulus in the intermediate temperature region can be increased by a factor of 100 or 200 pct, which improvement appears reflected in the reduced rate of peeling in roof service."

Mr. Hicks pointed out that, "In addition to work on a synthetic source of high-purity periclase, considerable work is underway in refractory laboratories to develop improved chromite sources or even synthetic chrome grains built up from beneficiated fine-grained chrome sources. Laboratory tests carried out over the past 10 to 15 years indicate that such synthetic grains can give satisfactory service, should considerations of supply or

(Continued on page 409)

Richmond section, AIME, held their first regular meeting April 5 in the Reynolds Metals Auditorium. William J. Harris, Jr., of the National Academy of Science, spoke on *Materials of Defense.*

During the meeting, which was attended by 50 members and guests, officers for 1961 were elected. They are: Thomas L. Fritzlen, chairman; Stewart Fritts, first vice chairman; George G. Ritchie, second vice chairman; and W. Fortune Smith, secretary-treasurer. Directors elected for 1961 are F. P. Battle, John H. Moses, James L. Perkinson, and Walter L. Rice.

Southwestern section, NOHC, has elected officers for 1961. They are: L. B. Lindemuth, chairman; S. M. Purcell, co-chairman; A. E. Hug, secretary-treasurer; and C. W. Searight, assistant secretary-treasurer.

The section's fall meeting will be held in Kansas City, Mo., on October 5-6. The Sheffield div., Armco Steel Corp., will be hosts for the meeting. There will be a plant tour on October 5, and the next day will be devoted to technical sessions.

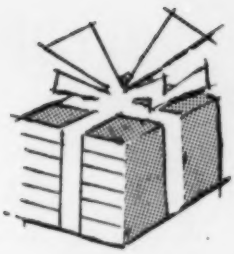
New York section, AIME, held a joint meeting with the Physical Metallurgy Group (which will soon become a sub-section) on March 23 at the Mining Club. Pierre Ledoux, new chairman of the New York section, was introduced to the group.

The first speaker of the evening was J. H. Wernick, of Bell Telephone Laboratories where he is concerned with semiconductor and magnetic alloy research and zone refining of metals. He discussed the *Purification of Metals.*

The second speaker, R. L. Smith, is head of the Metallurgy Dept. and coordinator of research at Michigan College of Mining and Technology. He spoke on *Mechanical Properties of High Purity Metals.*

Chicago section held its last technical meeting of the season on April 5 at the Chicago Bar Assn. with 48 members and guests attending. A. Alan Bates, vice president of the Portland Cement Assn. discussed *American and Soviet Uses of Engineering Materials.* He presented slides and movies showing typical examples of construction in the USSR and comparisons of similar types of construction in the US. This was followed by a discussion of construction materials in current use in this country.

Western section, NOHC, met April 19 for a field trip through the Bethlehem Steel Co., plant at Vernon, Calif. Following the plant tour, cocktails and dinner were served at Anderson's Restaurant. This was the section's last technical meeting of the season.



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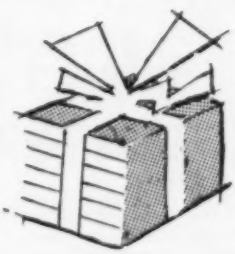

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personals

Laszlo J. Bonis has been appointed executive vice president of Ilikon Corp. Before joining the company in June 1960 as technical director, he was engaged in research and development at the high temperature laboratory of MIT.

John B. Caine, technical consultant to the foundry industry, recently presented the Charles Edgar Hoyt Memorial Lecture at the American Foundrymen's Society's Annual Congress in San Francisco. He spoke on *Cast Metals and Cast Shapes.*

Melvin C. Chang has been named supervisor of Youngstown Sheet & Tube Co.'s newly created raw materials research section. He was previously with Crucible Steel Co. of America.

Fordyce Coburn has been appointed director of purchases for Colorado Fuel and Iron Corp. He joined the company in 1951 as district manager of the Birdsboro, Pa., and Wharton, N. J. operations.

Jay I. Dobson has been appointed assistant superintendent in the metallurgical department, of Kaiser Steel Corp.'s Fontana, Calif., plant. He was formerly general foreman in the basic oxygen steelmaking shop.

Morris E. Fine, chairman of the materials research center at Northwestern University, has been named 1960's Chicagoan of the Year in Science by the Chicago Junior Association of Commerce and Industry.

John D. Goodall has joined Industrial Tectonics, Inc., as general manager of the Ball div. in Ann Arbor Mich. He succeeds **Helmut F. Stern** who remains as president of both the Ball and Bearing divs.

Thomas D. Hess has joined the sales staff of Basic, Inc., as assistant district manager. He was formerly with Youngstown Sheet and Tube Co.

F. R. Jeffery, president of National Zinc Co., Inc., has been elected president of the American Zinc Institute.

T. L. Johnston has joined the metallurgy department of Ford Motor Co.'s scientific laboratory. He was formerly with the Honeywell Research Center and was associate professor in the metallurgy department at the University of Minnesota.

John J. McGlone has been elected to the newly created position of vice president, sales, of both Wellman Engineering Co., and McDowell Co., Inc.

Frank R. Milliken has been elected president of Kennecott Copper Corp., to succeed **Charles R. Cox,** president since 1950, who will continue as a director and member of the company's executive committee. Milliken was formerly executive vice president.

Robert S. Miltenberger has been named manager, technical development, of Great Lakes Steel Corp. He was previously with U.S. Steel Corp.

Michael Orehoski is now chief research engineer, metal casting at U.S. Steel Corp.'s Monroeville, Pa., research center. He has been with the company since 1935.

Thomas A. Prater is now manager of the process laboratories unit at General Electric Research Laboratory. He was previously in the general engineering laboratory.

Walter C. Rueckel has been appointed vice president of Wilputte Coke Oven div., Allied Chemical Corp. He was formerly with Koppers Co.

R. W. Simon has been named vice president, metallurgy, of U.S. Steel Corp., replacing **L. J. Rohl** who retired April 30. Simon was formerly chief metallurgical engineer, steel operations.

Rudolph Smith has been elected executive vice president, operations, of Colorado Fuel and Iron Corp. He had been works manager of the company's Pueblo, Colo. plant.

T. B. Winkler is now director of research, processes, Bethlehem Steel Corp., with responsibilities including process metallurgy, chemical engineering, mechanical engineering, and ceramics. **D. J. Blickwede** has become director of research, applications. His responsibilities include physical metallurgy, chemistry, physics, and mechanics. Both men were formerly division heads.

Joseph C. Wijman has been named supervisor of physical metallurgy development at Beryllium Corp. Before joining the company he was senior metallurgist with International Nickel Co.

J. C. Warner, president of Carnegie Institute of Technology, has been elected to the board of directors of Dravo Corp.

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- Powder metallurgy and/or ceramics
- Physical metallurgy of high temperature alloys
- R&D welding programs
- Oxidation and corrosion mechanisms
- Protective coating and/or surface reactions

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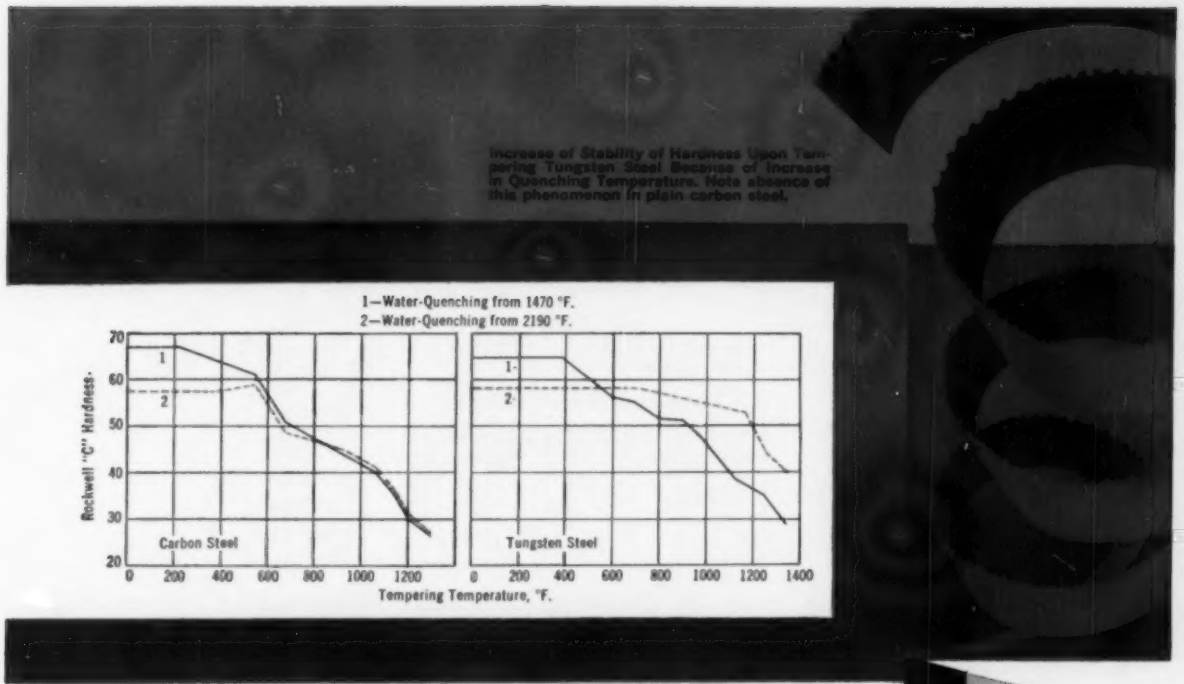

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Radiation Damage in Solids

Radiation Damage in Solids by Douglas S. Billington and James H. Crawford, Princeton University Press, 450 pp., $12.50, 1961. *Reviewed by J. A. Brinkman, Atomics International.* •

This book represents the most complete treatise written to date on the subject of radiation damage in materials. Radiation damage in most classes of solids is discussed from both the mechanistic and phenomenological points of view. It is, therefore, of value to the basic solid state scientist interested in the study of lattice defects, whether produced by irradiation or other means, as well as to the applied scientist or engineer interested in the changes which are produced in the properties of materials by various kinds of irradiation.

In many cases, the detailed models by which physical property changes have been proposed to result from irradiation by workers in this field either are not discussed or are presented in a rather cursory manner. For this reason the basic scientist may feel that this book lacks the depth which is desirable from his point of view. The applied scientist, on the other hand, may criticize the book for its inadequate coverage of radiation-induced changes in physical properties of materials. In this reviewer's opinion, the book represents as close an approximation to an ideal compromise between these two points of view as can be achieved in a book of this length intended for use by both groups. Adequate references are generally given to enable any reader to probe as deeply as he wishes into any specialized topic.

The organization of the book is good. First, the dynamical considerations of the manner in which irradiation interacts with solids, producing various kinds of lattice imperfections, are discussed. Second, the effects these imperfections have on the properties of solids are considered. Third, the pertinent kinds of radiation and the experimental means of their production are discussed. Fourth (the last three-fourths of the book), the effects of radiation on each of a number of kinds or classes of solid materials are described and related, where possible, with the theory developed earlier. In relationship to the amount of experimental work which has been performed, the treatment is probably most complete in the cases of semiconductors and covalent crystals and least complete in the case of uranium and other fuel materials. The length of treatment devoted to each material is, however, quite commensurate with the amount of basic understanding of the damaged structure which has been gained in each.

Aluminum Alloy Systems

Annotated Equilibrium Diagrams of Some Aluminum Alloy Systems by H. W. L. Phillips, Institute of Metals Monograph and Report Series No. 25, Percy Lund, Humphries & Co. Ltd., London, 86 pp., $4.65, 1959. *Reviewed by L. A. Willey, Aluminum Co. of America.*

In the middle nineteen-forties, the Institute of Metals initiated the publication of a series of Annotated Equilibrium Diagrams for important binary alloy systems, mostly nonferrous. The first nine of these were compiled by Prof. G. V. Raynor. The series has been continued by several authors with most of the diagrams for the aluminum alloy systems prepared by H. W. L. Phillips. In the preparation of these diagrams, the authors made a complete survey of prior literature, selecting only confirmed data or those which, in their judgment, appeared to be the most reliable data available. This series has been of considerable value to non-ferrous metallurgists.

In this book, Phillips has collected the 13 previously published diagrams with abridged annotations and has included seven additional diagrams for a total of 20 aluminum binary systems. Of additional value, has been the presentation of 12 ternary systems in a second section. Only those systems which can be considered of the greatest importance to the aluminum industry have been included. Furthermore, the aluminum-rich portions of the diagrams, including only those solid phases which exist in equilibrium with liquid and solid aluminum, have been shown and described. Adequate references to sources of information have been given.

Obviously, it was the intention of the author to limit the diagrams to the aluminum side. With the binary systems, particularly, this was a disappointment. For most of these, complete diagrams have been fairly well established and their inclusion would not have increased the number of pages to any marked extent. In fact, it would have been an aid in filling the partly vacant pages resulting from the abbreviated form of presentation. It would appear to this reviewer that complete coverage of the binary systems would have been well worthwhile even with questionable benefit to those interested only in aluminum-rich alloys.

The section of the book on the ternary systems is the most interesting. In this section, Phillips has presented a mass of information on the phase relationships for the aluminum-rich alloys in a concise but very complete form. Diagrams have been shown in detail for location of phases, for liquidus and solidus surfaces, for reaction between liquid and solid phases, and for limits of solid solubility (the solvus surface). Representative isothermal and vertical sections have been shown, also. Tables have been included under each system which give the locations, with respect to temperature and concentrations, of invariant points on liquidus and solidus surfaces and for the apices of three-phase fields in the solid state. Only the necessary annotations for completing the presentation have been given.

There have been omissions of some important ternary systems e.g.: aluminum-chromium with copper, iron, magnesium, manganese, etc.; aluminum-copper-zinc; aluminum-magnesium-manganese; aluminum-manganese-zinc, etc. This is understandable, since the published data for these systems are not sufficiently complete to meet the standards set for this publication. It is regrettable, nevertheless, that the available data for these systems were not included.

Regardless of these minor criticisms, this book is extremely valuable as a ready reference to those concerned with aluminum alloys.

An Introduction to Transition Metal Chemistry

An Introduction To Transition Metal Chemistry: Ligand-Field Theory by Leslie E. Orgel, John Wiley & Sons, Inc., 180 pp., $4.50, 1960. *Reviewed by Erwin Parthe, University of Pennsylvania.* •

The book gives a short and completely non-mathematical treatment of ligand-field theory and its applications to the structure and properties of transition metal compounds. It is complementary to the more mathematical treatment of ligand-field theory which has been written by J. S. Griffith, *Theory of Transition-Metal Ions*, Cambridge University Press, 1961. Both authors, who

(Continued on next page)

have collaborated for some time at the same laboratory, make particular reference in the introduction of their books to the complementary nature of the book of the other author.

The general approach to the chemistry of the transition metal compounds due to ligand-field theory depends to a large extent on the approximation by which one regards a transition metal compound as made up of individual metal atoms or ions, perturbed by their immediate environment (ligands), but interacting only weakly with each other. Therefore the metals themselves, their alloys, interstitial carbides can not be treated with ligand-field theory and are thus beyond the scope of the book. The book deals instead with the transition metal halides, oxydes, hydrates, cyanides, carbonyls and related compounds, where interactions between the transition metal d orbitals and the ligand orbitals are dominant.

The first chapters are devoted to the d-orbitals and their energies. Both electrostatic crystal-field theory and molecular-orbital theory are shown to lead to the same d-orbital energy-level diagrams. The ligand-field theory is now a hybrid approach to transition-metal chemistry, which uses the energy differences between various d-orbitals (ligand-field splitting) to account for property or structure characteristics without worrying greatly about the origin of the energy differences.

The third chapter deals with the competition between the intra-atomic exchange energy and the ligand-field energy. Large exchange interaction will lead to atoms with a large number of unpaired electrons having parallel spin (high-spin or weak-field compounds). Strong ligand fields on the other hand will stabilize atoms in configurations with lower numbers of unpaired electrons (low-spin or strong-field compounds). The factors controlling the ease of spin-pairing are then discussed for different transition metal ions in octahedral, tetrahedral and planar complexes.

The usefulness of the theory can be proved by checking certain physical properties for which predictions can be made.

From the many examples given in the book the following may be mentioned: a) *magnetic properties* like paramagnetic contribution to the susceptibility (distinction between high-spin and low-spin complexes); b) *stereochemical factors* like the distortion of octahedral d^9 complexes due to the Jahn-Teller effect (explanation for the structural abnormalities of cupric compounds) or the site preference of particular ions in spinel type structures; c) *thermodynamic properties* like the heat of hydration or the lattice energies of transition metal halides; d) *kinetic properties*, for example, the oxidation-reduction reaction rates for complexes; e) *optical properties*, for example, the change of the first absorption band with different ligands due to different ligand-field splitting (Tsuchida's spectrochemical series) or the differing absorption band width due to the Franck-Condon principle.

Most of the second part of the book is devoted to transition metal compounds with a higher degree of covalent bonding, where, covalent bonding is interpreted to be understood as *electron delocalization*. In Chapter 8, the different methods to determine electron delocalization are discussed. They include neutron diffraction, paramagnetic resonance (restricted to unpaired electrons), and nuclear magnetic resonance. Later chapters explain the stability of transition metal carbonyls, sandwich compounds like ferrocene $(C_5H_5)_2$ Fe, and other related zero-valent transition metal complexes. All these compounds are stabilized by a characteristic double-donor action and their composition follows the so-called inert-gas rule, which the theory explains satisfactorily.

The book is short and well written. Due to the non-mathematical approach, precision had to be sacrificed at certain places, but it is felt that this does not harm the intended purpose of the book. The book is directed to students of inorganic chemistry and to others seeking a general impression of this rather new field of valancy theory. It is not intended for professional theoretical chemists. Although the book does not deal with metals or alloys, it is felt that any metallurgist who is generally interested in the structure of matter should acquaint himself with ligand-field theory, and Orgel's book should be highly recommended for this purpose.

The Physical Examination of Metals

The Physical Examination of Metals edited by B. Chalmers and A. G. Quarrell, published by St. Martin's Press, Inc., New York, and Edward Arnold, Ltd., London, 900 pp., $30.00, Second edition, 1960. *Reviewed by J. J. Gilman, Brown University.* •

A scan of the chapters in the new edition of this book (first published in 1939) quickly gives an appreciation of how rapidly new diagnostic tools have been developed by and for metallurgists. Methods that were once considered unusual have now become commonplace and newer methods have begun to be established and soon will lose their novelty. The older methods have also become more sophisticated and specialized. This has necessitated a change in the mode of authorship for this book between the time of its first edition and the present. Instead of only two authors, this edition has seventeen, who wrote nearly the same number of chapters.

The thorough discussions of optical and electrical methods for examining metals which made the first edition so useful are augmented in the present volume. A series of chapters treats the older methods; including discussions of optical, electrical, magnetic, diffraction (X-ray and electron), electron-optical, and radiographic methods. The new topics that have been added to this are thermal (specific heat, cooling curves, conductivity, etc.), neutron diffraction, internal damping, ultrasonic, radioisotopic, microradiographic, and non-destructive magnetic methods. Some are applied to the determination of the structure of a metal, and others to property measurements. The nightcap is a chapter on vacuum techniques for handling hot or clean metals.

Even in a large volume like this one, such a large range of topics cannot be treated in full detail, but the outlines of the individual chapters are quite complete. Thus a reader can gain a thorough introduction to the topic of his special interest plus a good list of references for obtaining further details. In many cases, the material given in the book itself should give sufficient basis for launching an experimental investigation.

The book is well produced and authoritatively written. As a reference work, or an introduction to experimental techniques in metallurgy, it should prove excellent and is fully recommended.

The Encyclopedia of Spectroscopy

The Encyclopedia of Spectroscopy, edited by George L. Clark, Reinhold Publishing Corp., 787 pp., $25.00, 1960. *Reviewed by Charles F. Glick, Applied Research Laboratory, United States Steel Corp.* •

This comprehensive volume covers all types of spectroscopy, not only of radiation ranging from gamma-rays to radio-waves, but also of particles (β-ray, mass, and neutron spectroscopy). One nonspectroscopic technique, different thermal analysis, is also included. The subject matter is presented alphabetically, first by major topics, then by subtopics. Articles on *Absorption Spectroscopy* (Ultraviolet and Visible), *Emission Spectroscopy-Light* (optical emission spectroscopy), *Flame Photometry, Infrared Spectrophotometry*, and *X-ray Emission Spectroscopy* comprise the major part of the book.

In general, the basic theory, instrumentation, and applications of each type of spectroscopy are covered in a series or articles, each written by a recognized expert in

(Continued on next page)

Gordon Research Conf. Planned June 26-30 At Kimball Union Academy

The 1961 Gordon Research Conference on Physical Metallurgy will be held at Kimball Union Academy, Meriden, N. H., June 26-30. The general topic of the conference is *Imperfections, Substructure and Microstructure.*

In the field of imperfections and substructure, subjects to be discussed include methods of substructure analysis, the substructures of deformed metals and crystals grown from the melt, crystal nucleation from the vapor, short-range order and defects in alpha brass, the defect structure of dislocation-free crystals, direct observations of antiphase domain boundaries in superlattices and observations of the role of dislocations in precipitation.

Lectures concerned with microstructure will deal with proeutectoid structures, the isothermal decomposition products of austenite, structures produced by diffusionless transformations and by transformations at high pressure, the role of interfaces in transformations, the relation of annealing twins to surface topography, and a thermodynamic theory of the formation of microstructures.

Special attention will be paid to experimental techniques including field emission microscopy and electron microscopy. One lecture will discuss quantitative electron transmission metallography.

Additional information and application forms may be obtained from the director of the Gordon Research Conferences, Dr. W. George Parks, University of Rhode Island, Kingston, R. I.

New Books

(Continued from preceding page)

that field. The uses of spectroscopy for chemical analysis are emphasized, but the industrial applications of spectroscopy in research, testing, and process control are also discussed. These articles are authoritative and up-to-date; almost every article has a useful bibliography. The text is profusely illustrated with figures of excellent quality; many spectrograms and photographs of modern instrumentation are included.

Both *Emission Spectroscopy-Light* and *X-ray Emission Spectroscopy*, the topics of major interest to workers in the metals industry, are thoroughly covered. The various methods of exciting and recording the spectra, as well as the limitations, sensitivity, and accuracy of the equipment, are described. Although some of the other topics are of minor interest to such workers, these articles contain valuable background information on newer instrumental methods.

The treatment of the subject matter has a few weaknesses. First, there is a remarkable variation in the intensity and and extent of coverage of the sub-topics, and these variations are not always in proportion to their importance. Second, there is a considerable duplication or overlapping of the material presented in several related sub-topics. Third, there is no index or system of cross-referencing, only a table of contents. The reader unfamiliar with the entire contents of the book must therefore search several related subtopics page by page in order to find a specific fact.

Despite these shortcomings, the comprehensive, up-to-date nature of this single volume covering an enormous field makes it a useful addition to any technical library.

★ ★ ★

The Theory of Transition-Metal Ions, by J. S. Griffith, Cambridge University Press, 446 pp., $17.50, 1961. This book gives an account of the theory of the physical properties of the ions of metals having partly filled *d* shells in some or all of their compounds. It concentrates on non-cooperative phenomena such as paramagnetism and single optical spectra, but a study of the theory is also desirable for an understanding of cooperative phenomena such as ferromagnetism and anti-ferromagnetism.

THE INFLUENCE OF TEMPERATURE ON THE MECHANICAL PROPERTIES OF METALS AND ALLOYS

E. M. Savitsky. Edited by Oleg D. Sherby. This is the first English edition of a Russian study that has been recognized as a masterwork in the field of mechanical metallurgy. Much of the author's presentation of the mechanical behavior of metals and alloys at elevated temperature is new and original and not to be found elsewhere in English. The book is an excellent reference for research metallurgists, physicists, rheologists, mechanical engineers, and materials specialists.

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- The other is a "bull's-eye" network that monitors a restricted target area with extraordinary precision. This network is so sensitive it does not require the energetic explosion of a bomb but can detect the mere splash of a nose cone striking the ocean's surface—and precisely fix its location.

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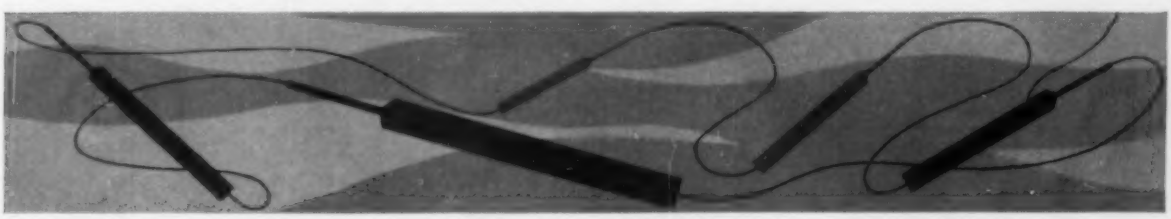

Office of Technical Services — "Clearinghouse" For Translations

Many scientists, technologists, and businessmen may not realize that there is in the Federal Government a central source of translations of Russian and other foreign technical literature as well as information as to where specific translations may be obtained.

Since July 1958, the Office of Technical Services, U.S. Department of Commerce, has been serving as a national translations *clearinghouse* to collect, catalog, reproduce, and distribute translations being done by agencies of the Federal Government and to collect and provide information on translations available from any other source, public or private.

This program is an expansion of the OTS program begun in 1945 through which the technical reports growing out of the ever increasing volume of US Government-financed research has been channeled to private science and industry. After World War II, OTS also had the task of collecting, organizing, and disseminating the technical documents captured from Germany and Japan.

Many scientific and industrial organizations have been making extensive use of this translations service; others have not, either through lack of knowledge of the program's existence or failure to investigate the services available.

The Office of Technical Services works in cooperation with the special Libraries Association Translation Center at John Crerar Library in Chicago. OTS concentrates its collection efforts on the material produced by agencies of the US Government and agencies of other Governments; SLA devotes its attention to the collection of material produced by private organizations. OTS has had wholehearted cooperation from the US Government agencies, particularly the intelligence agencies, who previously had the desire to make their material available to the public but, for intelligence reasons and lack of machinery through which to release the data, could not do so. Now, with OTS in full operation they turn their translations over to that agency for reproduction and sale to science and industry. The translating agency is not identified unless it desires this identification.

Technical Translations

In cooperation with SLA, OTS launched, in January 1959, *Technical Translations* which is published twice a month to announce and abstract new translations available from OTS, SLA, and any other source which advises OTS of its translations available to the public. This publication has over 2000 subscribers, and since January 1959 the volume of new material announced has increased to about 1,200 new items each month. About a fourth of these translations are available from OTS in printed form. Others are available from other sources also in printed form, while some of the items of more limited interest are available only in microfilm or photocopy from the Library of Congress or the Special Libraries Translation Center. *Technical Translations* are sold on subscription by Superintendent of Documents, US Government Printing Office, Washington 25, D. C. at $16 a year ($4 additional for foreign mailing.)

Most translations have limited sale, partly because of the nature of the material covered and partly because some potentially interested scientists and technologists are not aware of the availability of the material. In some cases, translations have had what OTS considers a very large sale. One such instance is a work by the Russian authority Ari Shternfeld on satellite science which was translated by the US Air Force, and when printed by OTS sold 600 copies. Now it has been reprinted by several commercial publishing companies, and OTS is no longer maintaining it in stock.

When especially interesting translations are published, OTS announces their availability through news releases to the technical, trade, and business press, which greatly increases the sale of the material.

Soviet Technical Press

A periodical recently begun by OTS is *Current Review of the Soviet Technical Press*, published weekly and sold by OTS at $7 a year, which reviews books and articles from the Soviet press usually within a month of their appearance in Russia. It covers the general spectrum of science, and runs about 30 pages an issue. This publication has over 600 subscribers and is increasing in distribution steadily.

OTS works closely wth the National Science Foundation. NSF itself helps support various translation activities, including the translation on a cover-to-cover basis of 45 Soviet technical journals. According to NSF, there are some 90 Soviet journals being translated in the United States on a cover-to-cover basis now available to subscribers. The NSF-supported translation programs are administered by professional societies and other organizations. A complete list of these

(Continued on page 402)

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Out-of-Print Volumes

Metals Branch TRANSACTIONS for the years 1949-1952 inclusive are currently out of stock. Arrangements have been made with Johnson Reprint Corporation to reprint Volumes 1-4 of JOURNAL OF METALS, including TRANSACTIONS. A discount price will be available to members of AIME. It is expected to have these reprinted Volumes available by the end of the year.

Thus it will be possible to obtain a complete set of Metals TRANSACTIONS from 1949 to the present. Orders for the years 1949-1952 should be sent to Johnson Reprint Corporation, 111 Fifth Avenue, New York 3, New York.

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SUBJECT:

nitrogen

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Nitrogen additions to steel are becoming increasingly important as a result of the continuing search for materials with greater strength at high temperatures. Many iron-based alloys available today depend, in part, upon a high-nitrogen content for elevated-temperature strength. Other new alloyed steels demand precise control over the quantity of nitrogen added.

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For full information on Foote Nitrelmang, write for your copy of Bulletin 201. Foote Mineral Company, 424 West Chelten Ave., Phila. 44, Pa.

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OTS Translations

(Continued from page 400)

translated Soviet journals is available on request from OTS.

NSF reports a steady increase in subscriptions to these cover-to-cover translations as well as an increasing tendency of U.S. scientific journals to cite references to these Russian journals because of their availability in English to the American scientist.

OTS expects a 10 pct increase in its own acquisitions of new material in the next year. One new program through which translation of books is being accomplished is the financing of translations in Israel, Poland, Yugoslavia, and other nations. This is done with funds accruing under the provisions of the Agricultural Trade Development and Assistance Act of 1954 (Public Law 83-480). Countries purchasing U.S. farm surpluses under this act pay local currency, which the U.S. is obligated to spend only in the country of purchase. By a 1958 amendment these currencies may be used "to collect, collate, translate, abstract, and disseminate scientific and technological information." Subject to approval by the National Science Foundation, Federal Government agencies such as Agriculture, AEC, National Institutes of Health, and Commerce's National Bureau of Standards can select material to be translated under this program. The program is coordinated by OTS and the translations are sold to the public at nominal prices by OTS.

Currently, the translating of approximately 50,000 pages of Russian material is contracted for in Israel; an agency in Poland will translate 19,000 pages of Polish scientific and technical literature; and Yugoslavia will translate 20,000 pages of Serbo-Croatian and other East European literature.

Many of the Israeli translations already are available from OTS, and the volume will be steadily increasing. They will be announced by news releases and also listed in *Technical Translations*.

Early in its program, OTS began collecting from an agency of the Government, and publishing for public use, cover-to-cover abstracts of about 140 Russian technical journals. This program was never widely used by the public, and in February of this year it was revamped to more nearly meet what was believed to be the desires of the scientific community.

Publishing of cover-to-cover abstracts was discontinued, and OTS now publishes abstracts selected from some 200 Russian, Communist Chinese, and other technical journals. These abstracts are sold by

(Continued on page 451)

Beryllium developments

Standard Beryllium recently announced that it will begin construction of a new mill in Brazil to process beryl ores from its Boa Vista property, located about 200 miles north of Rio de Janeiro. The plant is part of an expansion program initiated to fulfill the needs of the expanding beryllium industry. More than 80 pct recovery of beryllium is expected in the new plant which will employ Beryllium Resources, Inc.'s flotation method developed by E. Van Dornick. This process is the same one that Beryllium Resources plans to use at its Topaz Mountain properties in Utah. (See February 1961 issue of JOURNAL OF METALS, p. 139)

As another part of the program, the company is investigating a possible low cost beneficiation process based on electrostatic separation, and is also considering exploitation of some domestic ore properties. The program is designed to aid in supplying the beryllium market which consisted of 9500 tons in 1960 and is expected to triple by 1962.

Lithium Corp. recently announced that it is planning to produce beryllium in conjunction with Alloyd Corp. of Boston, Mass. Another US company—Vitro Corp. —is unofficially reported to be planning on entering the beryllium metal picture.

Foote Mineral Co. is operating a continuous pilot plant for processing and studying methods for separating beryl from spondumene (lithium ore) by the use of *soap* flotation. Beryl concentrates after separation from the lithium contain more than 6 pct BeO.

Strategic-Udy report

In the 1960 Annual Report of the Strategic Materials Corp. mention was made that the Venezuelan Government's proposed conversion of one of the electric furnaces at the Orinoco steel plant to the Strategic-Udy process had been delayed temporarily. However, a 275 ft. 11-ft diam kiln has been delivered to the plant site.

Recently Strategic Materials signed a licensing agreement with Lone Star Steel Co. for the use of the Strategic-Udy process for the production of carbon steel. This agreement represents the first license to an established domestic steel company for the ultimate production of standard grades of steel. With regard to two new Canadian iron projects, preliminary engineering has been completed and they are awaiting financing. One of the projects is the St. Lawrence Steel Co., formerly Quebec South Shore Steel Corp. of Montreal, and the other is New Mylamaque Mining and Smelting, Ltd., of Kingston, Ontario, Canada (See JOURNAL OF METALS, March 1961, p. 185). The New Mylamaque project is of special interest in that it proposes to utilize a deposit of titaniferous magnetite similar to Strategic's extensive holdings near Quebec. The report also mentioned that an option to acquire an iron smelter license had been given to Sovereign Resources, Inc. Preliminary engineering on a proposed plant in East Texas has been completed, but financing has not yet been arranged.

Nuclear stock-level gage

Stockray, a continuous nuclear measuring device for control of the burden level of blast furnaces, was developed by Republic Steel Corp.'s electromechanical research center. It will be manufactured and sold by Cutler-Hammer according to recent announcements. The high production rates of modern blast furnaces have focused attention upon the two major limitations of conventional stockline gaging systems—maintenance and gas leakage. Apparently the *Stockray* system has lessened or eliminated these problems.

The new system uses an arrangement of radioactive sources—Cobalt 60—which emit gamma rays from one side of the furnace toward a corresponding arrangement of radiation detectors on the opposite side. When the stock inside the furnace obstructs a radiation beam, the control circuit is notified, and the necessary adjustments can then be made. The device was described in a paper, *Nuclear Stockline Gage For Blast Furnaces*, presented by L. R. Stone at the 43rd Conference of the National Open Hearth Steel Committee, and Blast Furnace, Coke Oven, and Raw Materials Committee held in Chicago April 1960.

Semi-taconite beneficiation

A $2-million pilot plant to find an economical method of extracting non-magnetic iron particles for semi-taconite has been placed in operation at Cooley, Minn. by M. A. Hanna Co. If the project is successful, it will be possible to turn billions of heretofore worthless semi-taconite ore into useful blast furnace feed material.

In the pilot plant, a sink-float technique is applied to the crushed and sized ore. The density of the separation medium—a suspension of finely ground ferrosilicon—is controlled so as to permit the iron-bearing material to sink, while silicious gangue floats. The resulting concentrate is prepared for shipment, while the floated separation is further treated in a gas-fired kiln at 1300°F which converts the iron oxides into artificial magnetite. The kiln product is ground in ball mills and passed through magnetic separators; the final product is pelletized. The ore to be treated averages 32 pct Fe, while concentrates are expected to attain a level of 63 to 64 pct Fe.

New metal forming Co.

Electro-Hydraulics, Inc., is the first firm to enter the commercial field utilizing capacitor discharge techniques to form metals and carry out research and development programs. The Ft. Worth, Tex., firm plans to use the capacitor discharge unit in the production of air frame, missile, engine accessory fabricating and automotive manufacturing industry, and any other field where it might be useful. It will also be used for research and development in various fields such as geophysics, petroleum, chemistry, and metallurgy.

REPORTER

REPORTER

New hi temp material

Development of boron silicide, a new high-temperature material, has been announced recently by Allis-Chalmers research div. Boron silicide is resistant to corrosion because of a protective coating which results when the material is exposed to high temperatures in air. It is thought to be the only high-boron content compound that can be used at 2550°F in air for extended periods. Free silicon, the most objectionable impurity in boron silicide, is kept at an extremely low level by the exclusive purification process. The high-temperature powder lends itself to fabrication utilizing conventional powder metallurgical and ceramic techniques. Oxide-bonded boron silicide is readily machined with carbide tools when presintered at about 2000°F in air. After machining, the material exhibits virtually no shrinkage when sintered at 2500°F in air. Because of its 70 pct B content, boron silicide is applicable in nuclear reactors as a neutron control device, as shielding structures, and as a burnable poison to absorb excess neutrons in some types of reactors. In addition, its excellent oxidation and thermal shock resistance suggest uses in general refractory areas, particularly where other boron materials, such as boron carbide and boron nitride, cannot function at high temperatures in air.

Co-Cr-Fe alloy

The Cobalt Information Center has released the results of an investigation of a new cobalt alloy called *UMCo-50*. Containing about 30 pct Cr and 20 pct Fe, the alloy was developed about 10 years ago by the Union Miniere du Haut Katanga, but it has not been closely studied until recently.

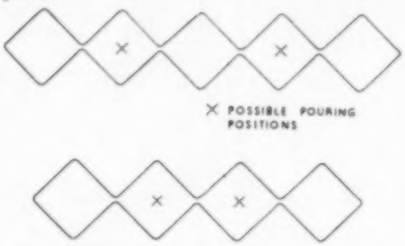
Small additions of Mo, Cb, and Ti may be made to enhance certain properties of the alloy which can be cast and forged easily. Its hardness in the wrought state is superior to that in cast form, and it has good tensile strength and adequate ductility at room temperature. In addition to satisfactory machinability with appropriate tools, the alloy is said to have excellent oxidation resistance, good resistance to corrosion (especially with Mo addition), and good thermal shock resistance and resistance to abrasion and wear at elevated temperatures.

Al from laterite

Yawata Iron & Steel Co.—Japan's largest steel producer—is planning to produce aluminum jointly with two other Japanese firms: Nisso Steel Mfg. Co. and the Konoshita Trading Co. Laterite ores, which are plentiful in Southeast Asia, have been found to be a suitable source of iron and aluminum. Company officials announced that they had developed a new process by which the aluminum content of the ore could be extracted after the ferrous content of the ore had been removed. Aluminum from these ores will be refined by Kaiser Aluminum's techniques.

Continuous casting

To increase the casting rates for a single-strand plant producing square sections to those rates which are obtainable with slabs, the Continuous Casting Co. and the British Iron and Steel Research Assn. have pioneered the development of a new continuous casting method based on a patented multiple mold shown in the accompanying figure. The process not only increases the casting rate for any square section, but it simplifies the tundish and nozzle operation, thus improving the reliability of the continuous casting plant operation.



Among the advantages of the new process are: reduction of the number of casting strands, cost savings, and operational reliability. A more detailed description of the new method, and additional technical facts appear in the April 7, 1961 issue of the *Iron and Coal Trades' Review* (British).

New coking process

The United States Smelting, Refining & Mining Co. and Victor Chemical div. of Stauffer Chemical Co. are jointly building a plant which will employ a new process for the manufacture of coke from Utah coal. Construction of the commercial retort and auxiliary coal and coke handling facilities is expected to be completed before the end of 1961 at a Midvale, Utah, site. The process was originated and successfully tested in the research laboratories of U.S. Smelting and is unique in many of its features, particularly in its ability to produce coke from western coals which are not amenable to existing coking processes.

Milled coal for BF

Production of milled coal for blast furnaces is being planned by the National Coal Board in an experimental plant at Ilkeston, Derbyshire, England according to the Financial Times. The program is part of a large-scale campaign to prevent the changeover to oil-fired furnaces by the iron and steel industry. Official sources have reported that blast furnaces can be operated just as conveniently and efficiently with the milled coal as with fuel-oil.

Columbium decline

Cancellation of programs to develop a nuclear-powered aircraft will result in at least a temporary setback in columbium development. Pratt & Whitney's Canel (Connecticut Aircraft Nuclear Engine Laboratory) reportedly utilized about 70 pct of last years' 200,000 lb of columbium produced.

NUCLEAR METALLURGY VOLUME VII

Metallic Moderators and Cladding Materials

Containing papers presented at the Symposium
sponsored by the Nuclear Metallurgy Committee, Institute of Metals Division
during the 1960 Fall Meeting

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Fabrication and Evaluation of Zircaloy-2 and Zircaloy-4 Tubing Used to Clad Uranium Dioxide and Aluminum-Plutonium Fuel	by R. C. Aungst, K. M. Haws, and P. L. Farnsworth
Mechanical Behavior of Cold Worked Nuclear Grade Zircaloy-2 Tubing	by H. H. Klepfer and C. N. Spalaris
Creep and Corrosion Behavior of Some High Strength Zirconium Alloys	by D. L. Douglass
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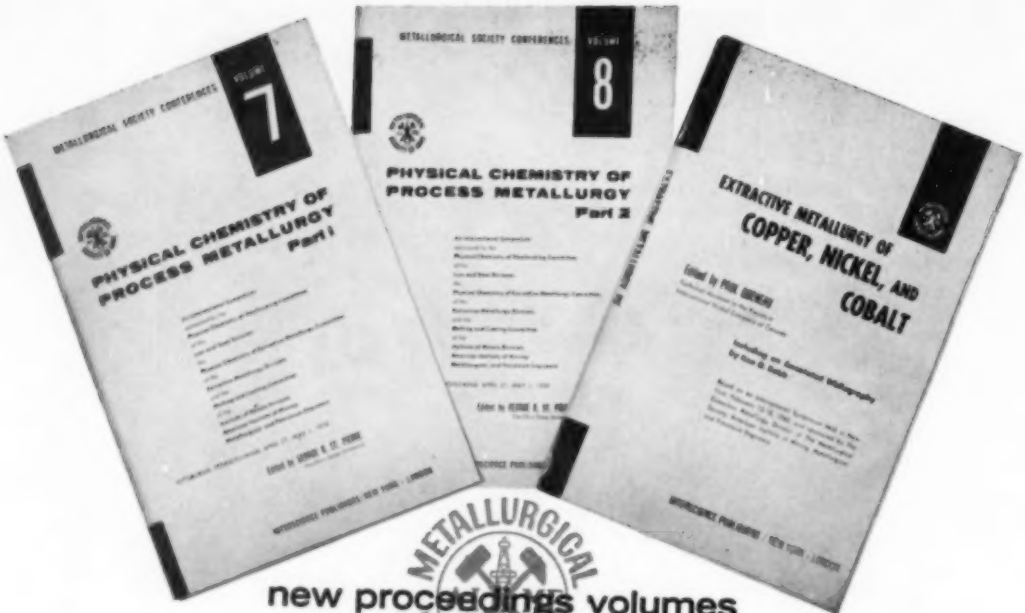
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editorial

The Partnership — Science and Engineering

[Recently, a copy of an address delivered by Philip Sporn, president of American Electric Power Co., came across our desk. We think that it has something to say. Ed.]

"Despite the close bond between science and technology, perhaps even because of it, there has developed a serious misunderstanding about the respective roles of science and technology . . . The confusion over the distinction . . . [between the two] . . . and the concept of the scientist that ascribes to him . . . many attractive qualities have resulted in a tendency in recent years to derogate engineering, which has affected the choice of careers by a significant portion of our high-school population. This has resulted in a decline in enrollment for engineering training in many of our schools, with an accompanying rise in enrollment in scientific training."

". . . this swing from engineering to science is cause for concern . . . because, if the present trend to elevate the importance of science at the expense of proper emphasis on engineering continues, our rapid rate of technological development may be seriously impaired."

"Consider . . . atomic energy. Early in the development of the fundamental scientific principles of nuclear fission many of our scientists recognized that its major peace-time application was going to be in the field of electric power generation. Many of those who made such significant contributions to the Manhattan District Project continued their work in atomic energy after Hiroshima and the end of the war. It was their scientists' viewpoint that dominated the early post-war development of atomic power generation. The result was a misdirection of effort and an induction of false hopes because of the failure to appreciate the problems of technological, as distinguished from scientific, development. The scientific basis for nuclear generation of electric energy was fully, or at least adequately known, but the difficulties to be overcome in the engineering implementation of the known scientific principles were overlooked. In particular, the engineering economic factors were not properly evaluated, and it was not adequately understood that the conventional fuel technology . . . was in a phase of dynamic change and progress which presented a moving target, so to speak. Even more, there was a failure to recognize that, in its essentials, progress in nuclear power technology could best be obtained by building upon the existing and highly advanced power technology.

"Some, but not all, of these errors have now been rectified and the fact that we are today quite well advanced along the road of making atomic energy competitive in the high-cost energy areas of the United States is due in large measure to the fact that for the last decade, at least, we have been concentrating on the engineering aspects of atomic energy generating designs rather than on the scientific aspects. Costs, questions of arrangement, questions of size, the problems of heat transfer, the problems of pressure supression in case of rupture of a vessel under pressure, the problems of metallurgy both within and without the reactor, the problems of thermodynamic heat balance—all are now being given the consideration they require."

"Much time was lost, however, before it was recognized from which partner of the science-technology team the real contribution was needed."

This is only one example. "Technology founded on scientific knowledge has made possible the present Western civilization with its high level of material welfare . . . Only by maintaining a proper balance between science and engineering can this progress be continued."

Said Johann Kepler: *"The planets move in elliptical orbits about the sun, and the square of their periods of revolution are proportional to the cube of their mean distances from the sun."*

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Information Service

The American Society for Metals is offering a brochure describing its new Information Searching Service. Briefly, it is a high-speed electronic machine which searches metals engineering and scientific literature, government reports, and metallurgical patents. This material is indexed and encoded on magnetic tape. An electronic selector is then able to select items of interest to individual subscribers, who get a comprehensive report every two weeks.

The brochure and further information may be obtained from the Documentation Service of the American Society for Metals, Metals Park, Novelty, Ohio.

Metallurgy Building at Case

The $2.7 million metallurgy building now nearing completion at Case Institute of Technology will be named the Charles M. White Metallurgy Building. Mr. White is former chairman of the board and chief executive officer of Republic Steel Corp.

A six-story structure containing approximately 71,450 sq ft of floor space, the new building will provide a variety of equipment for the investigation of the basic physical, chemical and mechanical characteristics of metals and other materials.

There will be special facilities for the study of metals under a complete range of environments, including temperatures, pressures, loading conditions and exposure to other elements. The building will be fully occupied by September.

Refractories . . .

(Continued from page 392)

severe service conditions justify the additional cost of preparation."

Citing increased density of the refractory material as one of the more obvious ways to reduce the rate of attack of fluxes upon refractories, Mr. Hicks said that, "Considerable work has been done over the years in studying the proper grain sizing and forming methods to secure optimum density." One result of these studies has been the recent adoption of the principle of the vibratory action press to the forming of basic refractories. The production of bricks by the fusion-cast process is also being used as a means of securing maximum density in refractories.

In conclusion, Mr. Hicks noted that, "While the consumption of basic refractories has increased from about 5 lb per ton in 1945 to perhaps 10 lb per ton in 1960, the overall consumption of refractories has declined from about 30 lb per ton to about 25 lb per ton in the same period. This is notable in view of the increases in furnace productivity. . . ."

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Make sure that manuscripts are typed double-spaced before submitting them to the JOURNAL OF METALS. Failure to do so results in retyping, chance of error, and needless delay. To facilitate matters, submit papers in duplicate and enclose illustrative material such as drawings and glossy photos at the same time. Such illustrations should be suitable for reproduction.

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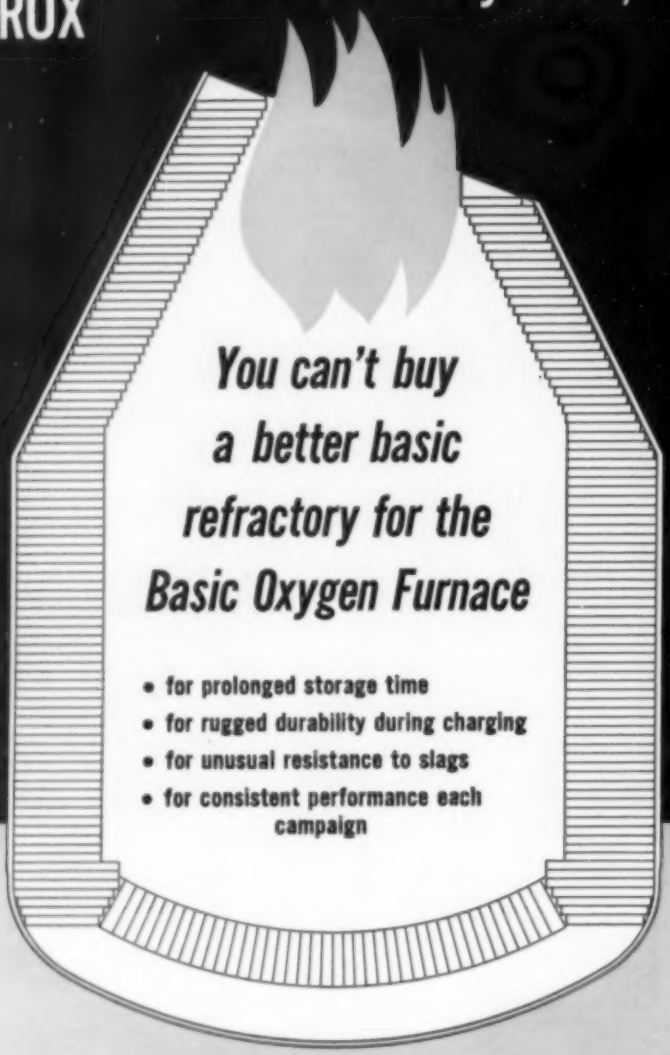

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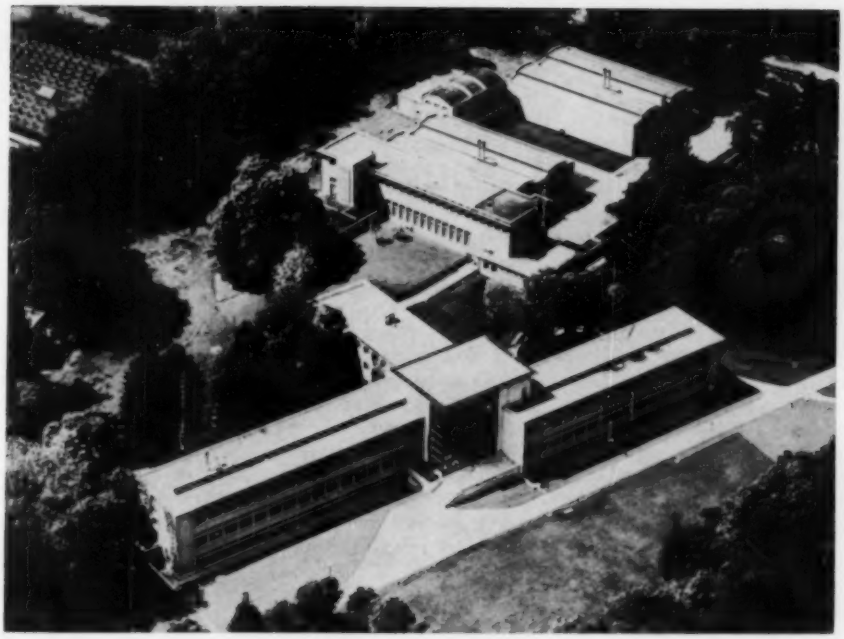


St. Germain-en-Laye

IRSID

Maizières-lès-Metz

Cooperative Steel Research in France

In a continuing series of articles, the JOURNAL OF METALS *has presented feature articles about some of the outstanding research facilities throughout the world. This article concerns the Institut de Recherches de la Sidérurgie better known as IRSID.*

by J. Astier and L. Wahl

J. ASTIER is head of the development in ironmaking div. of IRSID and L. WAHL, formerly with IRSID, is now with the central research organization of the Ugine firm in France.

References to research work up to 1958 have been published in two volumes: "Publication IRSID—Serie B" No. 29 July 1956 and No. 43 September 1959.

Birth and growth of collective research may well be one of the major facts regarding research at the present time. Importance of scientific equipment, as well as the broadening of scientific knowledge, leads to the creation of large establishments, with specialists of various fields working the same place.

This evolution had been foreseen in France by all those in charge of industrial activities and by the Government. During the period of World War II, the general principles, which were to lead to the creation of large technical centers, had already been settled. Financial asset would largely be derived from a levy on sold products, with the authorization of the government (remember that all prices were set by Government during that period, and this lasted some years after the war).

Before the war, in 1938, Professor Portevin suggested to the French steel industry the creation of a collective research organization. Naturally every-

thing was slowed down by the war, but still the *Institut de Recherches de la Sidérurgie* (IRSID) was officially born on December 1944, under the impulse given by J. Rist. The board was organized in June 1946, with H. Malcor as president and G. Delbart as general manager, and the building of the Saint-Germain establishment began a short time after. So, IRSID has now 14 years of existence.

In 1952, with the advent of European Coal and Steel Community, prices became entirely free, and thereafter Government did not interfere in financing IRSID. But the contribution of steelmakers, now voluntary, remained on the same level as before and even increased, thus permitting reasonable expansion of the new research organization while French steel production was rising.

IRSID's 1960 income was a little above $4 million. About 90 pct of this came from high-tonnage plants making low carbon or carbon steel. Special steel producers, having their own research facilities, contribute on a smaller basis. Contributions are fixed according to the products sold, and are on the order (for ordinary steel) of $0.32 per metric ton of finished product.

IRSID is thus organized on a cooperative basis by all of the French steel industry. But steel plants already have their own laboratories for control, routine work, and research. From these two facts, the general line of IRSID's research program may be clearly established. The main function of the Institute is scientific research applied to problems more likely to be solved by collective research than by individual investigation; it is also the study of problems which are of importance to the whole industry such as those concerned with raw materials and their processing and the properties of steel. As a rule, the results of each research project are published; while problems specific to one company, which desire to keep the results secret, are not usually studied.

Staff and laboratories

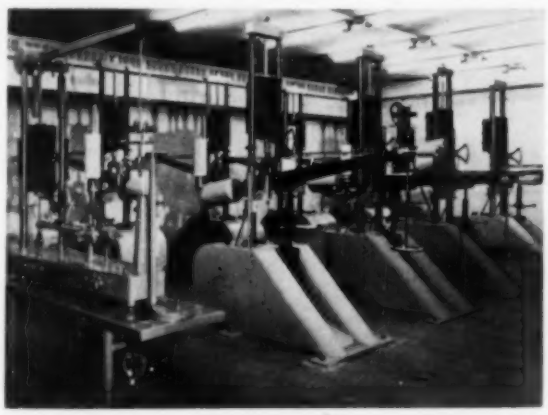
This year 570 people are employed by the Institute, among them 160 engineers (mainly metallurgical and mining engineers) or post graduates and 200 technical assistants. Research projects take place either in IRSID's laboratories at Saint-Germain, in the pilot establishment at Maizières-les-Metz, or in the plants.

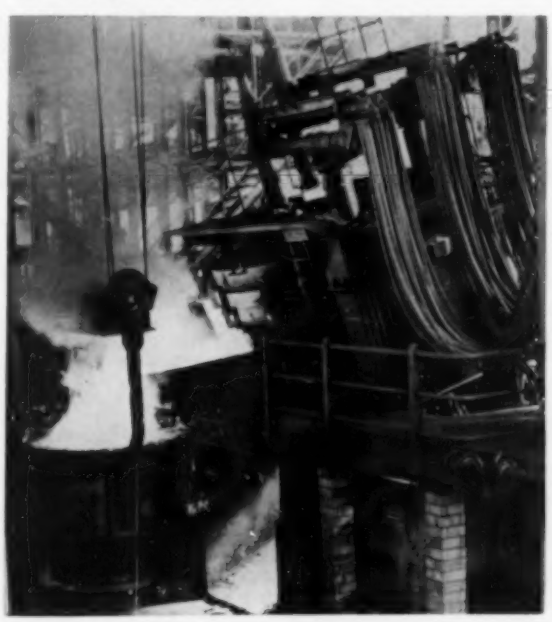
Main laboratories of the Institute are in Saint-Germain-en-Laye, 15 miles west of Paris. They were dedicated in 1952 and cover 140,000 sq ft of floor area. There are two groups of buildings: the laboratories and the machine shops. The laboratories are in a three-story building including basement, 372 ft long, with three wings in the shape of a T. The two frontal wings are devoted to research departments, while the central wing is occupied by management. This form of the building has been especially designed for possible extension. The machine-shops are essentially four large bays 117 x 42 ft, connected by one building housing the electrical power station. In these shops are housed the machine shop and small pilot units; on the side of these shops are mechanical tests laboratory, creep test rooms, and offices.

About 400 men and women work with IRSID in Saint-Germain. Fundamental research work is done in the physics, high temperature, physical chemistry, and flame departments. Saint-Germain also houses the chemistry, physical metallurgy, and mechanical testing departments as well as general services including machine shop and electronics, mathematical research (statistics), documentation and library, administration, and general management. There are also offices and some experimental facilities for the rolling mill department and for the steelmaking department.

The rolling mill and steelmaking departments mainly conduct research taking place in the plants. The same is true for the ironmaking division which is located in Maizières, near Metz in the middle of the Lorraine area, where 60 pct of the French steel is produced. The Maizières Experimental Station is on a 29-acre site provided with a railway spur; there are four shops: two for iron ore studies, one for hot metal testing, and one for the machine shop, plus three buildings for offices, chemical laboratories, and dining-room and guest facilities.

The two shops for ore studies are adjacent, 57x201 ft each, with a 10-ton overhead crane, flanked on one side by a one-story building for laboratory work. In the eastern bay there are facilities for crushing,





Above, Creep testing machines at St. Germain. Below, The 3000 kva electric furnace at Maizieres.

drying, grinding, screening, and finally taking representative ore samples for tests which are conducted on the other bay. Ore dressing by dry or wet methods and research on sintering is conducted.

The hot metal shop is a 69 x 201 ft building, 48 ft high with a 20-ton overhead crane. A 6-ton modern arc furnace of 3000 kva power input serves as a melting unit producing iron for steelmaking tests and enables research to be done on electric steelmaking. A 6-ton converter, oxygen storage, blowing equipment, small converters of ½-ton and 2½-ton capacity and induction furnaces are used for pilot tests.

The Ironmaking Division

The first objective of the Maizières laboratories was concerned with the use of the Lorraine ores. These so-called *minette* ores are ferruginous oolitic sedimentary ores with limestone, quartz, and sometimes iron silicates. About a quarter of the iron produced in France during 1960 was from these low-grade self-fluxing Lorraine ores. Even with a rather crude preparation, the coke rate before World War II was rather good in the Lorraine blast furnaces. As can be seen in Table I, it was possible with such self-fluxing ores, selectively and carefully mined, to make 1 metric ton of iron with about 0.950 tons of coke.

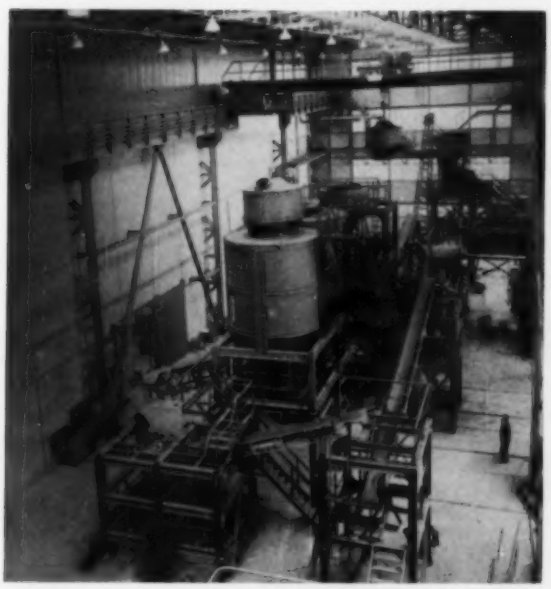
After the mechanization of the iron mines, blast furnace operations were badly affected, and it became necessary to prepare the burden by crushing, screening, and sintering. The results were very good, but the most promising results were obtained with high-sinter burdens. Table I shows that a coke rate of 1250 to 1400 lb per net ton of hot metal was obtained even with 1600 to 1800 lb of slag.

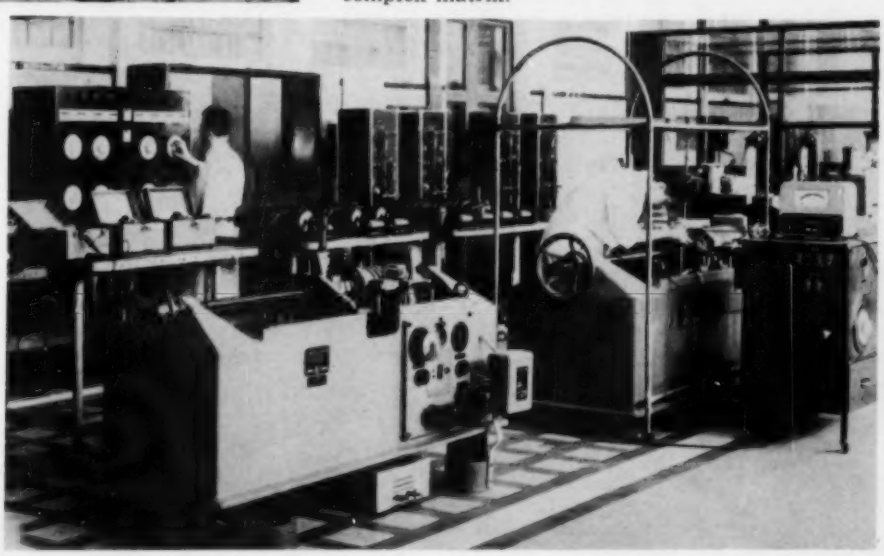
This low coke rate is, indeed a magnificent goal for industrial practice, and it justifies a great deal of research work in sintering and in blast-furnace practices. But there is another far-reaching goal—increased blast-furnace output. The use of a high-sinter burden with an accompanying low-slag volume makes possible greatly increased blast-furnace productivity. And this is one of the main reasons for the studies of Lorraine iron ores and their concentration.

Research on Lorraine Ores

One of the main objectives of the Maizières research establishment of IRSID is to provide the Lorraine district with adequate facilities for the study of *minette* ores. These facilities include: a geological bureau to make extensive surveys of the deposit and gather information about the reserves of commercial ores as well as low-grades ores which are not used at present; a mineralogical laboratory to make preliminary examination of small samples; and beneficiation facilities which include research laboratories and a pilot-plant station.

The geological bureau is quite a new development made with the agreement of the Mines Association (Chambre Syndicale des Mines de Fer) to set up a common organization with their facilities. The mineralogical study is a direct complement of geology and makes an introduction to the beneficiation research. We rely more and more upon the fractionation techniques which enable us to obtain a clearer idea of the structure of the Lorraine iron ores by separation of quartz grains and ooliths from the complex matrix.





Above, Iron ore beneficiation plant at Maizieres.

Right, Mechanical testing room at St. Germain.

From this team work between miners, geologists, and beneficiation engineers, it is quite possible that a new approach to the Lorraine iron ore problem can be found. Miners can find new methods to exploit the larger seams and by concentration, it should prove possible to give to the steel industry higher-grade concentrates. In that respect, the possibilities of open pit mining (which, for the present, is restricted to a small area of the deposit) is being considered in connection with the low-grade iron formations which have never been considered as iron ores.

With regard to concentration processes, the objectives of future work in Maizières can be divided in two parts:

First, the *classical* flowsheet using high-intensity magnetic separation. Tests will be done in a 5 tons per hr continuous pilot circuit which is fully equipped with crushers, dryer, screen, and one commercial-type high-intensity magnetic separator. This year one industrial plant will start operation, making 750 tpd of concentrate using this kind of flow-scheme.

Second, new concentration scheme. Laboratory research is being conducted in several fields, such as gravity, concentration (especially by spirals and jigs), flotation, and magnetic roasting. Some promising results have been obtained by flotation and a continuous pilot flotation circuit will be built in the near future.

The flotation of calcite in Lorraine iron ores is now working well at the laboratory stage. The work in that field was pioneered 10 years ago in the US by research workers at the Tuscaloosa Station of the US Bureau of Mines. By an agreement between the Bureau of Mines and IRSID the first tests were done by several methods, and later in France, IRSID developed in its laboratory some improvements toward a cheap flotation process for calcite.

The main part of our work in flotation is now aimed at a separation between ferruginous ooliths and silica. This problem is not very easy, but some work has already been done in the US and more recently at Maizières. We have some promising results in the labs and must now duplicate them at the pilot-plant stage.

Improvement of Burden

IRSID has been extensively studying sintering during the past few years. At the Second International Symposium on Sinter, which was organized in Paris by IRSID in 1957, several papers from the French steel industry and from IRSID contributed to the understanding of the sintering process and to the use of sinter in the blast furnace burden.

There are a number of research projects on coke, especially on coke quality and the development of the utilization of local coal (Lorraine coals) in coking plants. A large part of this program is conducted, partially sponsored by IRSID, at the Marienau experimental coking plant, some 40 miles east of Maizières-les-Metz, near the Saar border. A number of results have been obtained in past years, and some of them pertaining to improvements of the cokefaction process as well as for fluidization of coals have been presented at AIME meetings by Loison and Foch. One of the most promising results obtained may well be the industrial charging of dry and hot coal in the coke mix, thus enabling better production to be achieved from the coke ovens.

Blast Furnace Operations

In past years IRSID has devoted a large part of its activities in the blast furnace department to a study of the operations of blast furnace using Lorraine iron ores. We have already given some conclusions regarding the burden. Looking toward the future, our main objectives in this field can be divided into four sections.

Our first objective is, of course, to understand what actually happens in a blast furnace. It means a number of calculations starting from material and thermal balances to obtain some kind of *model* of the blast furnace. An important stage was reached when J. Michard was able to give recently an explanation of the operation of a blast furnace with a 100 pct self-fluxing sinter. With such a burden, it is indeed quite possible to describe the metallurgical operations and predict the results.

In the second place, we are gathering more information from laboratory research, on the blast furnace slags and on the reduction and fusion of sinter. We are especially interested in the melting point and melting range of the slags which would be obtained by using increasing tonnages of concentrates in Lorraine blast furnaces. It is indeed quite a new type of burden, and it seems necessary to get more fundamental knowledge about it before using it in commercial blast furnaces. Since we are contemplating a large increase in sinter content of the burden, more data about the constitution of this project and the mechanism of its reduction are also quite necessary.

In a third part of the research, we have to make a laboratory study of a number of problems related to the design of future blast furnaces. We refer to large blast furnaces using a high sinter burden to achieve a high rate of iron production. The initial emphasis was on the use of new processes, such as the introduction of gas and oil in the blast furnaces. Tests have been done in commercial blast furnaces to be sure about the influence of the introduction of oil, or gases in the tuyeres, and a paper on that subject was delivered by J. Cordier from IRSID at the

Table I. Some Coke Rates of Blast Furnaces Using Lorraine Iron Ores

Ore Preparation	Coke Rate		Slag Volume	
	lb/net ton	kg/metric ton	lb/net ton	kg/metric ton
Pre-war practice with carefully and selectively mined iron ore (34 pct Fe)	1900	950	1800	900
Post-war practice with				
a) mechanized mines and coarsely crushed ores with fines (30 pct Fe)	2200	1100	2200	1100
b) prepared burden: crushed and screened ores and sintered fines (crude ore 30 pct Fe)				
30 pct sinter	1830	925	2200	1100
60 pct sinter	1700	850	2200	1100
c) 100 pct self fluxing sinter (crude ore 34 pct Fe)	1250 to 1400	625 to 700	1600 to 1800	800 to 900

1960 Blast Furnace Conference and printed in the January 1961 issue of JOURNAL OF METALS.

The last part of our program pertains to tests in industrial plants. It seems useful not only to gather operating data but to get information on what really happens outside of the blast furnace. So, we are now taking samples of gas and solids inside the stack; this can be a way of improving the control of blast furnace operations.

We must stress the importance of the experimental blast furnace at Liege; the former International Low Shaft Furnace which was a cooperative research project of several European countries, especially France and Belgium. The furnace is now used on tests with 100-pct sinter burden. Oil has been injected at the tuyeres, and it is intended to use the furnace to test Lorraine concentrates as well as new processes.

The Steelmaking Division

Research made in the Steelmaking division covers the field from hot metal in the blast-furnace runner to the ingot mold. Two parallel lines are followed: one consists of understanding and improving classical processes such as open-hearth or basic bessemer, and the other developing new processes for pretreatment and refining of hot metal. In that respect, the new pilot-plant of Maizières is of great help.

Pretreatment of Hot Metal

In the early years of IRSID, high silicon in hot metal was a very serious problem for basic bessemer plants, because it caused heavy slopping during blowing. So, extensive studies were conducted on the prerefining of hot metal with pure oxygen leading to two industrial methods: one in the ladle, by top blowing with a water-cooled lance, and the other in the runner itself by injecting pure oxygen through porous bricks inserted in the bottom of the runner. This method allows a continuous desiliconizing with the supplementary advantage of producing no red fumes.

Desulfurization tests have also been conducted and a new process was tried. This was the first in a series of IRSID processes, which made use of the injection of powdered materials into the metal bath. By blowing finely-divided burnt lime through hot metal, very high desulfurization efficiencies can be obtained (JOURNAL OF METALS, September 1957). This process has been used on a small scale in foundry practice, but in large-scale steelmaking units, drawbacks due to important losses of iron beads in the dry slag and heavy ladle sculling prevented its development.

Basic Bessemer Process

At the beginning of IRSID, the activity of the steelmaking division was mainly concentrated on the understanding and improvement of the basic Bessemer process which was responsible for about 2/3 of the French steel production. The rate of blowing was first improved through an exhaustive study of the hydro-dynamics in the vessel. This was based on model work conducted in the well-known hydraulics Laboratory of Neyrpic in Grenoble (now called Sogreah Laboratories). It enabled factors controlling the slopping observed in the first part of the blow to be defined and resulted in changing the design of the vessel. Most of the basic converters in France, and in Western Europe have been modified according to the results of this study.

Another line of research was based on a study of the thermal and chemical evolution of the metallic bath; this is especially difficult since the refining time is on the order of only 10 min. The use of a two-color pyrometer, developed by IRSID, made possible the continuous recording of bath temperatures from the beginning to the end of the blow. From these recordings, obtained by aiming at the bath through a hole at the bottom of the vessel, studies of nitrogen evolution and of dephosphorization have been developed. Along that same line, another method of recording bath temperature by optical measurement through the converter nose has been developed. This has lead to complementary results on nitrogen pick up during carbonization, and allowed a good prediction of final temperature of the blow —a result of great practical importance. As in other countries of Europe, many tests have been made with oxygen-enriched air.

A third step has been to widen the range of silicon content of hot metal for the basic bessemer converter, and again for techniques of blowing lime has led to the development of a new process. By adding lime powder to the wind blown from the bottom of the converter during a short period, silicon in hot metal is immediately neutralized and slopping can be avoided. Previously, it was nearly impossible to blow hot metal when its silicon content was above 0.6 pct; this limit has been shifted to above 1 pct by this new method.

Open Hearth Process

Concerning open-hearth practice, as far as the chemistry of the process is concerned, studies have been made on the oxidizing power of slags, sulfur pick up from fuel oil of various sulfur contents, and bath carburization by carbon-powder injections. It must be remembered that, because the French phosphorus irons are most generally blown in basic converters, the open hearth is used in France as a scrap-melting process, with only a small percentage (20 pct) of hot metal or pig iron. With very few exceptions, high percentages of high phosphorus iron have been used only temporarily, explaining why early tests with oxygen injection into the bath were not carried through. The same applies to a series of tests conducted in two plants with injection into the bath of lime powder suspended in an oxygen stream.

In view of these facts, the main problem in French open-hearth shops is scrap melting, not refining, and, for this reason, most of our activity in the matter was devoted to combustion and heat transfer studies. Thus, successful work has been done on oxygen enrichment of producer gas, and also with Sogreah Laboratories, on scale model studies of aerodynamics in the combustion of preheated fuels. Nevertheless, an important part of the work was the practical application of the theoretical knowledge obtained on the experimental furnace operated at Ijmuiden in the Netherlands by the International Flame Research Committee to which IRSID is actively participating.

For rich gas or oil, as well as for low-calorific preheated gas, practical tests have confirmed the findings of the fundamental research concerning the advantages, for melting, of burners with a high fuel momentum, giving a short hot flame. A longer larger flame is, on the contrary, best for heating and refining a completely melted charge.

On the other hand, methodical trials relative to the use of oxygen for combustion have shown that, in all cases (lean preheated gas or non-preheated rich gas or oil), the best way of using oxygen is to inject it under the burner. By carefully selecting the relative position of this oxygen injector, it was proved by series of tests conducted in several open-hearth shops that the furnace could be speeded up without damage to the refractories, and with appreciable saving in fuel.

It is thus worth stressing the results obtained in a 180 ton open-hearth furnace, charged with 20 pct hot metal, giving a steady production of 45 net tons of steel per 1000 sq ft of hearth (tap to tap), with 4.2 million Btu and 800 cu ft of oxygen per ton of steel.

OLP Process

As previously stated, IRSID is a pioneer in the industrial application of lime blowing, using it to desulfurize hot metal and to improve the basic bessemer operation. A natural extension of this was the oxygen lime powder steelmaking process (OLP). IRSID was first in producing steel by this method, and results were given at the 1958 AIME Annual Meeting (JOURNAL OF METALS, July 1958). Very accurate lime blowing equipment, developed after years of research, gives great flexibility to this process.

OLP low-carbon steels made from high phosphorus hot metal have mechanical properties at least as good as the best open-hearth steels of the same grade. Moreover, production of carbon steel from that type of phosphorus hot metal has now been successfully developed. Pilot-plant tests have shown that the OLP process can be applied to any type of hot metal, and in the large field of hematite hot metal it can lead to improvement of the top blown processes.

At present, the rapid industrial development of the OLP process at full industrial scale covers both the high phosphorus and hematite hot metal ranges, with converters up to 140 tons capacity.

Other Research

Along the same line, mention should be made of a study at Maizières of the recovery, without combustion, of gas coming from top-blown converters. In addition to the recovery of a high calorific gas there are the advantages of simpler gas cleaning equipment and a lower power consumption. The 140-ton OLP converters of France's largest oxygen steel plant will be equipped with that process.

Concerning electric furnaces we should mention studies of the magnetic stirrer and its influence on evolution of bath composition, recarburization, and dephosphorization when accompanied by injection of finely-divided powder and use of preheated scrap.

The problems of the casting bay have also been deemed worthy of considerable attention. Rimming and capped steels have been considered. Extensive studies on ingot molds—design and conditions of use—have carried out and have brought about substantial economies. At the present time, attention is also devoted to vacuum casting of ordinary steels.

Fundamental and applied research

Almost 70 pct of IRSID's total income is devoted to research in the area of iron- and steel-making. Included in this figure is the fundamental research done for the industrial divisions. Many of the results would not have been achieved without a foundation of fundamental research.

Various properties of steel, such as the mechanism of rupture and ageing, have been thoroughly studied. In that respect, mention should be made of the many possibilities which are opened by the microprobe microanalyser (JOURNAL OF METALS, April 1957), which IRSID developed with the help of a research institute in aeronautics (ONERA) and Professor Castaing. This instrument makes possible the quantitative analysis of elements in an area as small as 1 sq micron, permitting studies of segregation, inclusions, etc.

It is not possible to describe the activities of each of the research departments in this paper, but the programs of the laboratories can be classified under seven major subjects:

1) Studies of solidification, including segregation, inclusions, and distillation under vacuum;
2) Studies of rupture, including deep-drawing and texture, brittle fracture, fatigue, and intergranular fracture such as creep;
3) Studies related to steelmaking;
4) Studies related to ironmaking, including the viscosity of slags and the mechanism of desulfurization in the blast furnace;
5) Studies of corrosion, including gas corrosion such as surface oxidation and wet corrosion;
6) Studies of gases in steel and ageing; and
7) Miscellaneous studies, including pyrometry, spectrography, non-destructive testing, and the use of radio-isotopes in industry.

It must be stressed that much of this research began with fundamental studies, leading to a better understanding of basic phenomena. Thus, the mechanism of desulfurization in the blast furnace has been explained through lengthy measurements of superficial and interfacial tension and the influence of sulfur on carbon-iron melts. The mechanism of fatigue rupture has been explained by a mathematical study of the theory of damage. In this context emphasis should be given to one of the main advantages of a rather large establishment like IRSID where one can find in the same place specialists in numerous fields who can look at one problem from various points of view.

IRSID—a research organization

There are two directing committees of IRSID. One of these is the Technical Committee to which research programs are submitted. Its members include representatives of industry and the technical schools and universities. The other body is the Board of Directors on which sit general managers of the major French steel companies. This body is responsible for general policy and finance.

IRSID takes part in the various technical meetings of the engineers of the iron and steel industry, either those concerned with the processing of steel or those concerned with properties. Thus, a good exchange of information exists between industry and the scientists and engineers of the Institute.

It must never be forgotten that IRSID is a creation of the steel industry, and that its aim is to study problems of interest to that industry. IRSID has become a sort of scientific and technical brain trust for the steel industry. It is a good example of the achievements which can be attained by cooperation within an industry.

A New Approach to LADLE DEGASSING —BOTTOM BUBBLING

During vacuum degassing of molten metal in a ladle, only the upper layers of the metal are subject to the action of the vacuum. In order to increase degassing efficiency, IRSID developed the bottom bubbling technique. This paper describes the process and presents results of pilot-plant tests.

by J. Duflot, J. Verge, and E. Spire

Advantages of vacuum degassing molten metal have been emphasized by many studies. Most of the processes which have been developed are applicable to large ingots for subsequent forging into quality products. It was with the view of extending the benefits of vacuum treatment to many types of steel currently cast into medium sized ingots for rolling that the current studies were undertaken.

The efficiency of ladle degassing of metals is generally reduced because only the upper layers of the metal are subject to the action of the vacuum. But the process developed by IRSID in collaboration with Air Liquide[1] avoids this problem by blowing inert gas through two porous plugs which are permeable to the gas but not to the metal. In addition to the resultant stirring action, the inert gas purges the molten metal and dilutes the gases above the bath. The porous plug process has been described at various AIME conferences and elsewhere.[2-5]

Pilot-Plant installation

The experimental installation built at IRSID's pilot plant at Maizières (Fig. 1), consists of: a treatment ladle, a vacuum chamber, and a apparatus for gas evacuation.

The treatment ladle is similar to an ordinary ladle except that two porous plugs have been inserted into the bottom to permit the influx of gas. The plugs, are installed in much the same manner as a nozzle, and have a life of about 12 melts. The influx of gas —either nitrogen or argon—is controlled by observing the stirring action and is generally maintained on the order of 3.5 to 5.0 cfm per plug. This ladle also serves as the tapping ladle for the pilot plant's 6-ton electric furnace.

The vacuum chamber consists of a bell equipped with sight holes and a vacuum lock for solid or liquid additions. The bell is placed on a base plate through which the vacuum and inert gas pipes pass. When the bell is in position on the base plate, an air-tight seal is formed.

In order to evacuate the gases, a pumping system composed of a turbo-blower acting as a vacuum pump is used. This blower is capable of attaining an initial pressure of 190 mm Hg, and a compressed air ejector reduces the residual pressure down to 20 to 25 mm Hg. A filter is employed in order to prevent dust problems from arising in the system.

After tapping, the ladle containing the metal to be treated is placed on the base plate; the flexible gas pipes are connected to the plugs; the bell is placed into position for the seal; and the pumping system is started. In the beginning, the surface of the bath is primarily agitated by the stirring effect; however, as the treatment progresses, the effect is accentuated both by the release of gas in the metal and by the expansion of the bubbling gas under vacuum conditions. Normal treatment times range from 6 to 15 min.

The inert gas flow must be closely controlled, especially at the beginning of the operation when deoxidation action is the controlling factor. Flow rates above 7.0 cfm per plug can lead to an overflowing of the ladle. Efficiency of the treatment depends directly upon the degree of vacuum, the intensity of stirring obtained, and the length of treatment.

Results

The following were obtained from 100 tests of degassing hot metal and steel under an average vacuum of 25 mm Hg.

The hydrogen content of the hot metal decreased from 4.5 to 2.5 cu cm per 100 g or an overall decrease of 45 pct, whereas the nitrogen content decreased from 0.010 to 0.006 pct or an overall decrease of 40

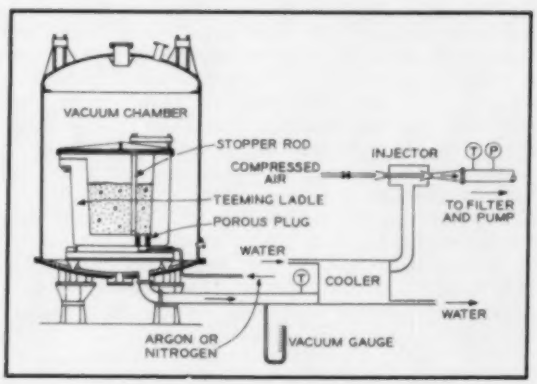


Fig. 1—Experimental vacuum treatment unit.

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pct. Since treatment times as long as 20 min showed no appreciable improvement over shorter times, degassing apparently occurred during the early minutes of the operation.

The hydrogen content of killed steel decreased from 4.5 to 2.7 cu cm per 100 g, or a decrease of 40 pct, and the nitrogen content again decreased from 0.010 to 0.006 pct for a 40 pct decrease. In order to degas killed steel effectively, treatment times of at least 6 min were necessary.

For the rimming steels tested, the hydrogen content decreased about 45 pct, with a corresponding decrease of 35 pct in the nitrogen content. Stirring was observed to increase during the treatment of rimming steels, undoubtedly resulting from the evolution of carbon monoxide. Investigations showed that the CxO product decreased about 50 pct for the treated steels. With rimming steels, treatment times of less than 6 min were sufficient to degas the bath effectively.

It is worthy to note that a denitriding effect was observed in the samples, even when nitrogen was employed as the bubbling gas.

In specific tests, graphite was added to rimming steel to promote deoxidation at the expense of decarburization. Deoxidation efficiencies of better than 70 pct were obtained for treatments ranging from 8 to 10 min, and oxygen contents as low as 0.005 pct were attained in the presence of carbon contents of 0.06 to 0.07 pct.

The results have shown that by employing a suitable bubbling technique, it is possible to accelerate ladle degassing and to increase its efficiency. Further improvements could probably be attained utilizing a higher vacuum and longer treatment times.

This process is significant in that it provides an extension of vacuum treatment to medium-sized ingots at only slightly increased investment and operating costs, and with slight heat losses.

The flexibility of the process permits possible development and application concerning:

1) the treatment of steel for which low hydrogen contents are of interest;

2) a decrease in the quantity of deoxidizer required for killing certain types of steel;

3) the degassing of certain additions made in liquid form (cupola-melted ferromanganese and ferrosilicon) which are known to introduce gases into the metal and which could be degassed in small-capacity installations or treated by the producers;

4) the achievement of very low carbon contents for certain steels by means of slags or suitable bubbling gases;

5) the injection under vacuum of alloying elements or deoxidizers in pulverized form, by means of techniques already developed by IRSID; and

6) the extension of the process to nonferrous metals, e.g. copper and aluminum.

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OLP STEELMAKING

Recent Studies and Industrial Progress

In July 1958 the JOURNAL OF METALS *presented the initial test results on the Oxygen Lime Powder (OLP) steelmaking process developed by IRSID in France. This article is a progress report on more recent studies and on results achieved in industrial installations.*

by B. Trentini, P. Vayssiere, and C. Roederer

In February 1958, IRSID presented at the AIME Annual Meeting the first paper on refining hot metal with lime powder in suspension in a stream of pure oxygen—the OLP process.[1] Since then, important work has been done on this process, and the large OLP plants being built have the combined benefit of systematical studies made by IRSID on a model scale, on a pilot-plant converter, and on full-scale vessels.

The OLP process makes use of a stream of pure oxygen which takes fluidized lime from the bottom of a dispenser and injects this lime powder in suspension in oxygen into the bath through a vertical, water-cooled lance. All of the lime needed for refining is blown as lime powder.

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Since burnt lime is easily crushed, the powder blown has a very fine grain size—about 95 pct-28 mesh and 60 pct-100 mesh. At the tip of the lance, oxygen expands into a cone and quickly looses its speed, whereas lime remains in the same direction and retains its speed much longer. The difference in behavior between a jet of pure gaseous oxygen and a jet of oxygen containing lime powder in suspension has been shown by the calculation of the momentum. The composite stream has a much higher momentum, i.e. higher penetration power, than the jet of pure oxygen. This penetration power of the composite jet, increasing with lime concentration, and the high reactivity of lime due to its very finely divided form play an important part in the evolution of the bath composition during refining by the OLP process.

An important part of the activity of the melting shop of IRSID's Maizières pilot plant has been concentrated on pure oxygen refining, mainly according to the OLP process. Hot metal to be refined in the 6-ton experimental converter is provided by a modern arc furnace of the same capacity and with a maximum power input of 3000 kva. This combination provides a great deal of flexibilty as far as the starting composition of hot metal is concerned and has proved to be of great value in extending the range of the OLP process.

The following are some of the studies carried out in this pilot plant:

Refining different types of hot metal

The OLP process was developed initially for refining high-phosphorus hot metal with about 1.8 pct P and 0.5 pct Si. The industrial installations built at USINOR-Denain and at Dillingen (Saar) blow that type of hot metal. But it has been proved that the process could easily be applied to the low-phosphorus hot metal produced in the US. The flexibility of lime powder blowing permits the refining of much more difficult types of iron such as those rich both in silicon and phosphorus and, at the same time, low in carbon. Such iron, industrially produced for example by low-shaft electric furnaces, has been refined successfully by the OLP process.

In the following example, taken from a series of more than 30 similar heats, the starting hot metal contained 2.45 pct C, 2.65 pct Si, and 1.35 pct P. Blowing is divided into three phases, as is shown in Fig. 1. The first phase—mainly a desiliconizing—terminates with the removal of a slag rich in silica but already basic. The second phase—dephosphorizing—results in a high-phosphorus slag that can be used as a fertilizer. In the third phase carbon is reduced to the desired level. Details of the treatment of the above-cited hot metal are as follows:

First Phase
Lime blown: 160 lb/THM
Total oxygen: 1120 cu ft/THM (gas + ore)
Metal: 1.97 pct C, 0.22 pct Si, and 0.82 pct P
Slag (removed): 44 pct CaO, 30 pct SiO_2, 7 pct P_2O_5, total Fe 11 pct

Second Phase
Lime blown: 84 lb/THM
Total oxygen: 580 cu ft/THM
Metal: 0.84 pct C, 0 pct Si, and 0.25 pct P
Slag (removed): 59 pct CaO, 10 pct SiO_2, P_2O_5 20 pct, total Fe 6 pct

Third Phase
Lime blown: 96 lb/THM
Total oxygen: 350 cu ft/THM
Final metal: 0.060 pct C, and 0.016 pct P

For this type of iron—high in silicon and phosphorus—lime consumption reached 340 lb per ton. Such a quantity has to be dissolved according to a given pattern in order to produce intermediate slags in a given range of composition. The flexibility of the process allows the fulfillment of these requirements, which would probably be much more difficult with the addition of lump lime.

Continuous recording of bath temperature

It is generally recognized that it would be of great interest to know the bath temperature during heat in a top-blown converter. From a theoretical point of view, this temperature curve could probably explain a great deal of the difference of behavior between heats of apparently similar starting conditions. And from a practical point of view, such a curve would allow the final temperature to be attained within reasonable accuracy without undue difficulty. The same also applies to the termination of the first phase of a high-phosphorus blow.

Different methods of recording a temperature curve might be devised, but few of these could be used on an industrial scale. IRSID has approached the problem by aiming a two-color pyrometer through a hole in the converter bottom. It is with this same apparatus, devised by IRSID, that one of the authors recorded temperature curves on several hundred of basic bessemer heats[2]. The pyrometer is aimed through a hole which is kept open by a flow of an inert gas such as nitrogen. On a large-size converter, this flow is negligible compared to the flow of oxygen blown with the lance and would lead to only a very small pick up of nitrogen, not detrimental to steel quality in most cases.

Scrap preheating

The preheating of scrap is a very timely subject; it is known that this can be done in the top blown converter. In IRSID's pilot plant, a series of tests have been conducted with an oxygen-fuel burner devised by the Flame Division of IRSID. Scrap is charged into the empty vessel held in the vertical position and preheated for a few minutes. High local temperatures are avoided in order to minimize oxidation and prevent the formation of liquid FeO which is detrimental to lining life and requires heat for its later reduction in the metallic bath. In pilot-plant tests, scrap has been heated to about 600°C.

In the treatment of high-phosphorus hot metal the situation is more difficult. In order to increase metallic efficiency, the final slag, rich in iron oxide, is retained for the following heat. In this case, part of the scrap added becomes coated with that slag, thus making preheating less efficient. More experiments must be made along this line.

Iron oxide injection with oxygen

Iron ores of very fine grain size are readily available at a low price on the world market, and they would appear to be an interesting subject for injection into a top-blown converter. Injection can be made with lime powder in the OLP process as has been done by IRSID, but for industrial use the problem of lance and pipe wear would create a problem.

There is another way of injecting fine ores. It is well known that inside of a top-blown converter

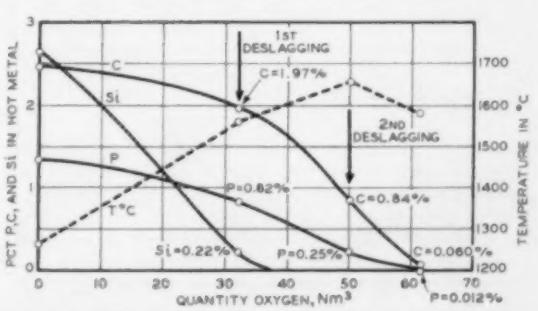

Fig. 1—OLP treatment of hot metal containing 2.65 pct Si, 1.35 pct P, and 2.45 pct C.

the gases are mainly carbon monoxide, and that burning them to carbon dioxide inside of the converter itself would lead to an increase in thermal efficiency as well as a shortening of lining life. But fine ore particles could absorb a part of that heat, and for this purpose a second water-cooled lance may be introduced into the converter. It blows iron-ore fines in a stream of oxygen. There is a flame at the tip of the lance due to the combustion of carbon monoxide, and the ore particles, before reaching the bath are heated by that flame. Due to its lower momentum, the carbon dioxide does not touch the bath; thus, oxidation of metallics in the bath by carbon-dioxide does not occur.

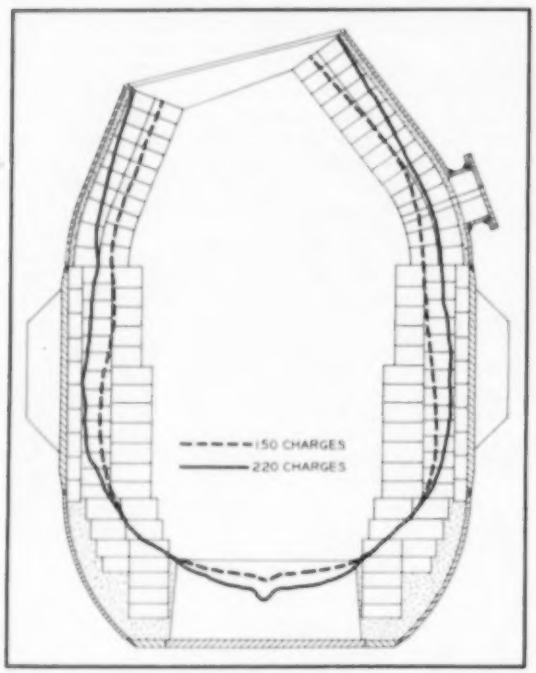

Fig. 2—Profile of a 30-ton OLP vessel at Dillingen.

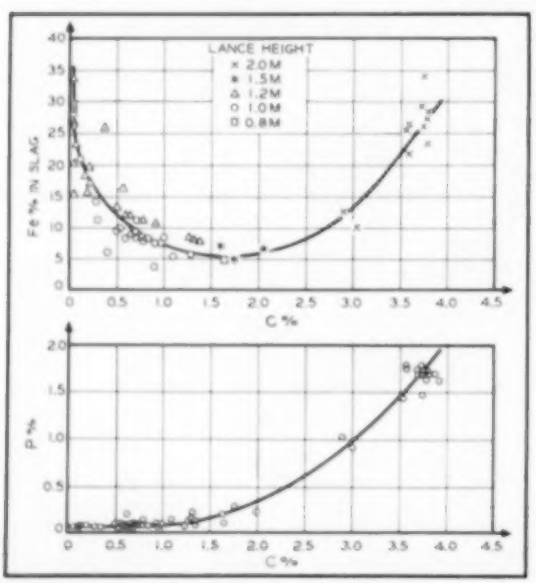

Fig. 3—Changes of iron content in slag and phosphorus content of metal during first phase of OLP treatment of high-phosphorus hot metal.

Industrial results

The paper on the OLP process presented at the 1958 AIME Annual Meeting[1] referred to a temporary installation built at the USINOR plant (in Denain, France) for testing the validity of the new process. The next step consisted of building complete OLP units in two different steel plants. Since these new OLP converters were located in the same aisle as existing basic bessemer converters, their capacity was determined by the size of existing cranes and ladles. Thus there are two 60-ton OLP converters at USINOR-Denain and two 30-ton OLP converters at Dillingen in the Saar.

In both plants, the hot metal is high in phosphorus —about 1.8 pct—and requires about 230 lb of lime per ton of hot metal when the final slag is recovered from the preceding heat—a practice followed in most OLP heats (when this is not used, lime consumption must be increased by about 40 lb). Thus, for a 50 ton charge, 12,000 lb of lime are needed; and all of this lime is blown as fine powder in suspension in the oxygen stream. Lime concentration may have to be varied from 0.02 to 0.5 lb per cu ft of oxygen during the blow, and at Denain flows of more than ½ ton per min are reached. These flows can be controlled and adjusted to the desired values in a few seconds.

Average oxygen flows at present are 2200 cu ft per min on the 30 ton vessel at Dillingen, and 4200 cu ft per min for the 60 ton unit at Denain.

Fig. 2 is a view of the dolomite brick lining of a 30-ton converter at Dillingen, with the profile of this lining at different stages. The small notch at the center of the bottom, corresponding to the lance axis, shows the penetration power of the composite jet of oxygen and lime powder.

In refining high-phosphorus hot metal, the final slag is basic and, in the case of low-carbon heats, contains more than 25 pct Fe in the form of oxides. Since the weight of this slag is well above 200 lb per ton, its recovery becomes economically interesting. Accordingly, this slag is maintained in the converter for the following heat.

The upper curve of Fig. 3 shows the evolution of such a slag during the first phase of a blow. Iron oxide content decreases progressively due to its reduction by silicon, carbon, and phosphorus in the metallic bath. The minimum iron oxide content depends upon lance height, lime concentration, and oxygen flow. That minimum generally is reached at about 1 pct C when the iron content of the slag is between 5 and 6 pct. Partial deslagging is done at that time, and this slag, with over 50 pct CaO and 20 to 25 pct P_2O_5, is excellent as a fertilizer. Precautions must be taken to prevent the entrapment of iron beads when violent foaming occurs at the end of the first phase. In certain cases, iron loss from these beads is higher than the iron oxide loss. Under normal conditions, iron yields of more than 93 pct are obtained. But it should be noted that the recovery of iron from the slag requires heat for iron-oxide reduction. Consequently, the amount of scrap to be melted (600 lb per ton hot metal) is systematically about 160 lb less than for heats without slag recovery.

The lower curve of Fig. 3 represents the dephosphorization during the blow, and indicates that at

the time of deslagging (about 1 pct C), the phosphorus content of the bath is on the order of 0.150 pct. From that point, the rapid formation of a highly basic slag results in a very low phosphorus content—for example 0.015 pct—in the final low-carbon steel.

Recently, it has been demonstrated that medium-carbon steel can also be produced by the OLP process from high-phosphorus hot metal by *catching* the carbon. Early dephosphorization on a high-carbon bath is achieved by changing lance height, lime concentration, and oxygen flow. With these heats the problem is not one of dephosphorization, it is rather one of carbon scatter. The slag formed is entirely out of equilibrium with the metallic bath, and carbon evolution occurs during *dead* time. Thus, the final results depend on the length of these dead times which must be held as constant as possible.

Lining life is a question of primary importance. Since high-phosphorus hot metal requires a much greater quantity of slag than the low-phosphorus grades, it is easily understood that good slag control is a necessity. Foaming of silicious slags must be avoided, because they literally wash the lining and considerably shorten its life. Slags low in lime tend to pick up lime from the lining; hence, lime consumption in the process is maintained between 200 and 260 lb per ton of high-phosphorus hot metal when the final slag is recovered and about 40 lb more when there is no slag recovery. Under these conditions, the tar-dolomite linings of the OLP vessels have a life of over 200 heats, corresponding to a dolomite consumption of 20 lb per ton of steel produced from high-phosphorus hot metal.

Due to the large amount of basic slag produced and its partial removal from the high-carbon bath, the desulfurization efficiency of OLP heats is on the order of 70 pct. Thus from a hot metal containing 0.050 pct S, a steel with 0.015 pct S is obtained, and with preliminary hot-metal desulfurization, sulfur contents of 0.010 pct and less can be achieved.

Nitrogen in steel depends primarily upon the purity of the oxygen blown, except when there is a reblowing at the end. With an oxygen purity of more than 99.5 pct as at Denain, the average nitrogen content of the steel is 0.015 pct.

In regard to steel quality, results obtained in mechanical testing laboratories and in customer's laboratories confirm the high quality of OLP steels which are similar to the best open-hearth steels of the same grade. A paper has been published concerning low-carbon OLP steel[3], and recent data on carbon steels will be given at the 1961 Fall Meeting of the French Metallurgical Society.

Conclusions

Due to satisfactory results obtained on an industrial scale, there is a rapid development of the OLP process in France and in other countries. The size of OLP vessels under construction and being planned is above 100 tons. The new steel plant at Dunkirk in France will use the OLP process on 140-ton converters for refining low-phosphorus hot metal.

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COLLECTING UNBURNT GASES FROM OXYGEN CONVERTERS

Pilot-plant tests on the recovery of refining gases without combustion during oxygen steelmaking are described in this paper. Advantages of lower cost dust collecting units and the recovery of useful gas decided in favor of the installation of an industrial unit at the new Dunkirk steel plant.

by M. Allard, P. Vayssiere, and G. Namy

In the refining of hot metal in top-blown oxygen converters, the gases—composed principally of carbon monoxide—are usually burned in the hood with a large excess of air and then cooled. Before releasing these gases into the atmosphere it is necessary to remove the finely-divided, iron-oxide particles. Thus, the operation of top-blown converters requires the collection and cleaning of a considerable quantity of fume, and this necessitates the installation of bulky and costly auxiliary equipment.

To avoid these disadvantages, the volume of gas to be treated should be reduced to a strict minimum. This can be accomplished by collecting the gas directly at the nose of the converter before combustion. Once this gas, rich in carbon monoxide, has been cooled and cleaned it is possible to make

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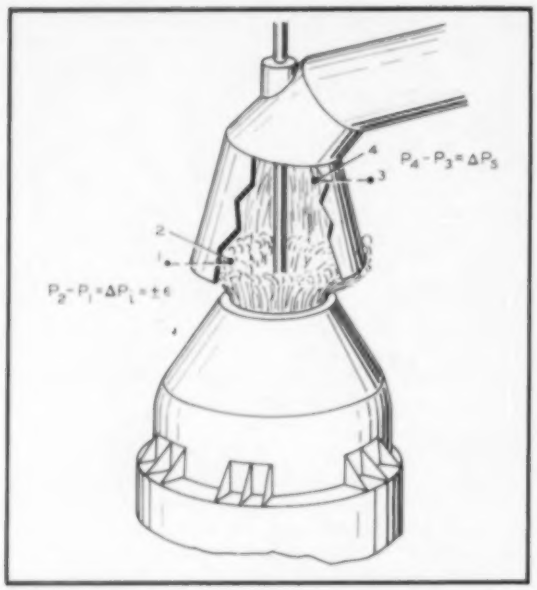


Fig. 1—Recovery of gas without combustion by the Pressure Control Process.

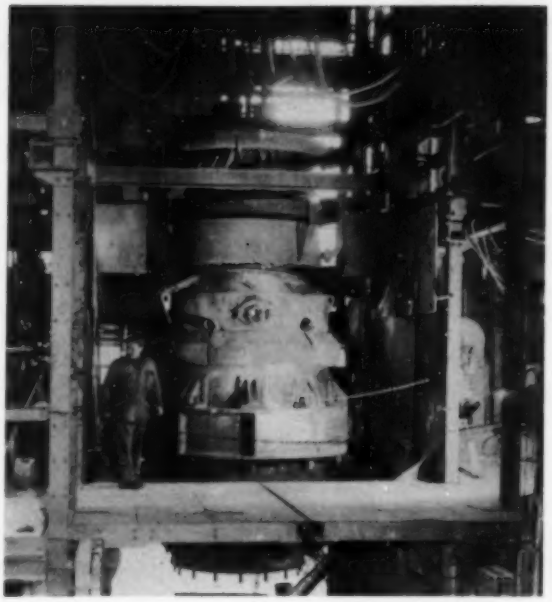
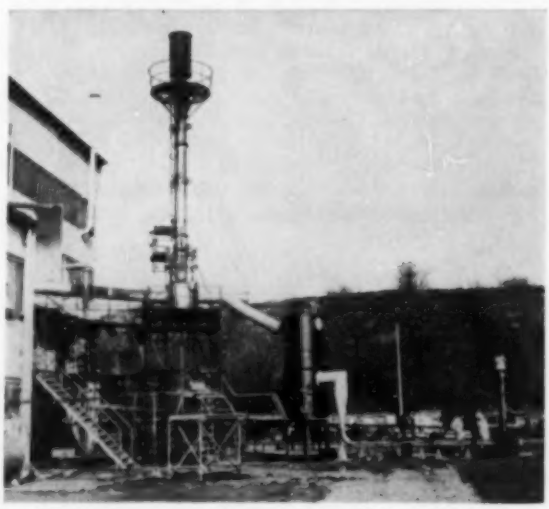


Fig. 2—Above, Pilot-Plant converter with hood. Fig. 3—Below, Collecting and dust-cleaning installation.



use of its appreciable calorific power. The reduction in the cost of auxiliary installations and the economic advantage of the recovery of a usable combustible gas have led to the development of IRSID's and CAFL's processes.

In the pressure-control process, despite the absence of a mechanical seal between the hood and the converter, the entry of air and the escape of gas are minimized, as is shown in Fig. 1. A stationary combustion zone is created for the trapped gases whose limited contact with the atmospheric air gives rise to turbulence only at the periphery of the gap between the hood and the nose of the converter.

In order to maintain the desired pressure at the base of the hood, whatever the conditions of refining and the phase of the operation, the draft of the whole system—hood-gas evacuation to dust collection—must be adjusted. The pressure difference at the base of the hood can be used to control the regulation of the draft system. However, studies have shown that a satisfactory measurement, which is more convenient in practice, is the static pressure difference between the inside of the hood and the atmosphere at a higher level.

Pilot-Plant tests

The 6-ton installation constructed at the Maizières pilot plant is the result of collaboration between IRSID and the French firm, CAFL, with incidental participation by the manufacturers of dust-control equipment. The installation, shown in Figs. 2 and 3, comprises:

1) a collection hood consisting of a water-jacket traversed by the oxygen lance and a gas-tight system for ore addition;

2) a gas conduit, water-cooled along part of its length, at the end of which the gases may be led either to a dust-collecting system or directly to the atmosphere; and

3) an automatic regulation system.

This system has been used on the OLP process treating hot metal containing 1.8 pct P as well as low-phosphorus hot metal with silicon contents from 0.1 to 1.7 pct. Charges were about 6 tons, and oxygen was supplied at a rate between 10 and 20 normal cu m per min. Lime concentration in the oxygen jet, as well as the cooling additions, were adapted to the composition of the hot metal and the phase of the operation.

Fig. 4 illustrates the composition of gases recovered from the second phase of the refining of a low-phosphorus hot metal with the carbon content reduced from 2.95 to 0.7 pct.

For charges such as this, gas pressure in the draft system was controlled throughout the whole operation so that a slight reduction of the draft would lead to an escape of gases toward the exterior. This is the so-called *equilibrium* of the draft system. The stationary zone in the hood then estab-

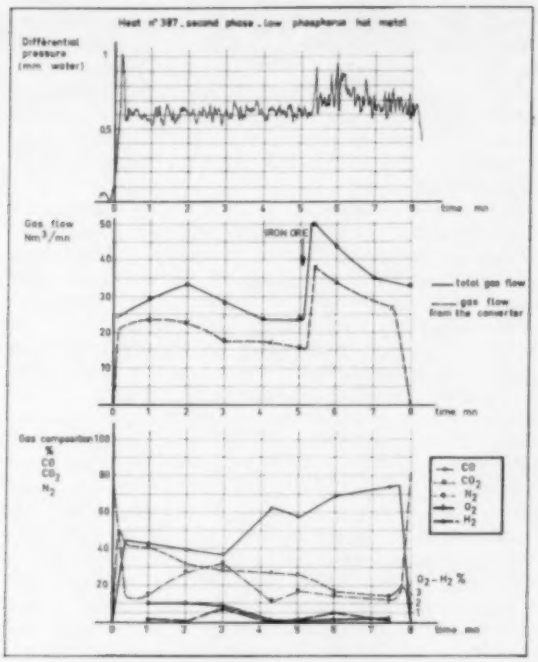


Fig. 4—Composition of gases recovered and pressure in the hood.

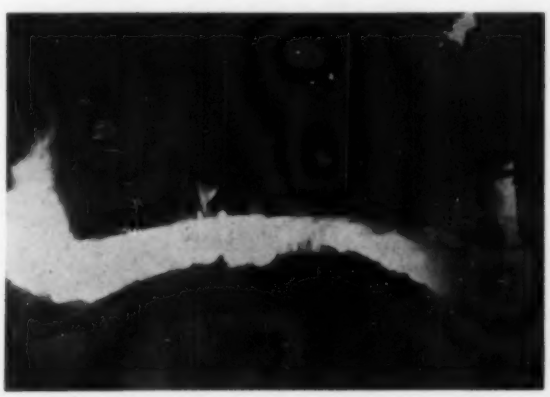


Fig. 5—Example of a stationary combustion zone.

lishes itself as shown in Fig. 5. Under such conditions, the carbon monoxide content of the gases is usually between 60 and 70 pct, although it can fall at certain times to 40 pct as determined by the composition of gases in the interior of the converter. For heats taken as far as extra-mild steel (0.030 pct C), a high carbon-monoxide content of the recovered gases persists even for the low carbon contents of the bath. The oxygen content of the gases is less than 2 pct, and the hydrogen content is practically nil, although it can increase during the addition of ore as a result of the dissociation of the water which it may contain. Nitrogen content is linked to air entry.

Fig. 4 likewise shows the pressure in the hood, the gas flow from the converter, and the total gas flow measured in the stack. The gas flow curves can present important peaks, as for example at the time of ore addition. The relationship between the maximum flow and the average flow is an important

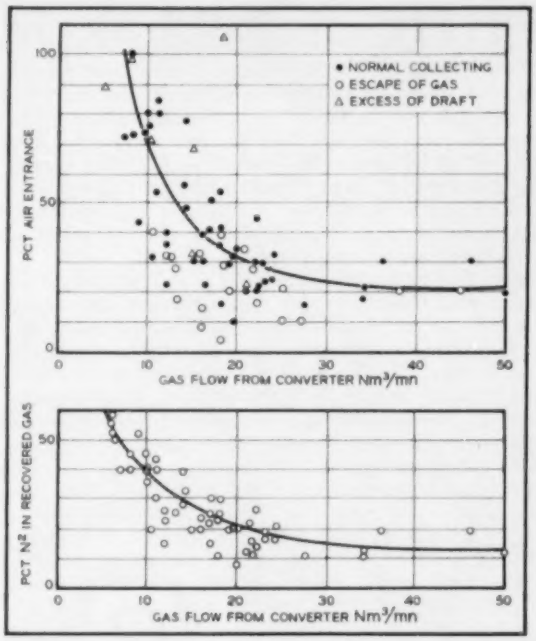


Fig. 6—Air entrance and nitrogen percentage at equilibrium conditions.

factor, since it influences the size of the dust collecting installation.

For equilibrium draft conditions air entry is not eliminated. This has been verified on a pilot scale as is shown in Fig. 6, which gives the rate of entry of air into the hood under equilibrium draft conditions. It should be noted that air entry is never nil, but it reaches non-negligible rates, and on the other hand decreases asymptotically when the gas outflow increases. Nevertheless, this inevitable air entry is not of great consequence. It decreases the carbon-monoxide content somewhat and tends to increase the temperature in the recovery hood.

In the same way that it gives rise to slight air entry, collection without a mechanical seal causes a slight gas escape due to possible dissymetries in the gas flow and external effects, such as strong air currents. This escape of gas constitutes a loss of carbon monoxide and causes certain inconvenience because the gas is charged with dust. The problem can be solved either by systematically increasing the draft above the equilibrium value or installing a collecting skirt, concentric to the hood and linked to a small evacuation circuit. It is also possible to reduce the gap between the hood and the converter by a closing sleeve.

Closing-Sleeve technique

The seal between the collection hood and the nose of the converter can be made by a movable sleeve, cooled by steam and resting freely on a flange welded to the shell of the converter. An injection of steam between the sleeve and its flange improves the tightness of the joint. At the Maizières pilot plant, the sleeve was formed with a double wall in which steam circulates with a water joint assuring the seal between the hood and the sleeve.

In order to assure good gas collection with this system, it is necessary to maintain a slightly lower pressure in the hood. Thus, the draft of the whole

gas evacuation system must be controlled accordingly, but this control is perhaps less precise and is simpler than that of the preceding technique.

Projections of slag or metal during refining do not stick to the wall of the hood, but the flange must be cleaned from time to time. During foaming, the slag has occasionally risen in the converter and reached as far as the hood, but the solidified slag is always very brittle and hinders neither the removal of the movable sleeve nor the tilting of the converter. However, this phenomenon may be of importance in industrial converters.

Fig. 7 shows a gas analysis for a heat refined to extra mild steel with the closing-sleeve technique. Except for an initial period of about 3 min, the carbon monoxide content is normally between 60 and 75 pct. This dispersion is due to variation of the pressure inside of the hood caused by insufficiently precise pressure regulation. As might be expected, the best results were obtained with a differential pressure between the hood and the atmosphere approaching zero. In such a case, the average carbon monoxide content is on the order of 70 pct with a maximum of about 80 pct. The injection of steam at the nose of the converter has only a slight influence on the hydrogen content which is normally limited to about 4 pct.

Discussion

The collection techniques described in this paper require the treatment of only one eighth of the volume of gases handled by conventional techniques. The result is a large drop in the consumption of energy and a considerable reduction in the size—hence cost—of the installation. This advantage is all the more important for larger oxygen steelmaking installations.

The collection of gas without combustion makes use of 80 normal cu m of gas per ton of metal. The calorific value of this gas is about 1900 Kcal per normal cu m with an average carbon monoxide content of about 63 pct. This gas can be used separately or mixed with another gas of lower calorific power, such as that from the blast furnace. The rather unfavorable conditions of these tests carried out on a small converter give rise to estimates that gas recovered in an industrial collection installation on larger oxygen converters would be richer in carbon monoxide and could attain values between 70 and 80 pct CO, thus having a calorific value of 2100 to 2400 Kcal.

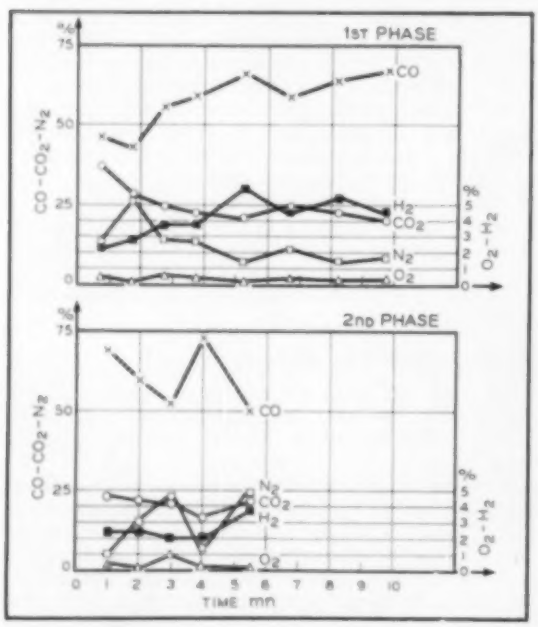


Fig. 7—Gas recovery with closing sleeve technique.

The nature of the dust from the collection-without-combustion system is different from the dust obtained in normal collection procedures. Red fumes arising from the combustion of oxygen converter fumes with atmospheric air contain very fine particles—less than 1 micron in size. The particles are sometimes agglomerated and principally composed of iron oxides accompanied by a small proportion of impurities, such as manganese oxide or lime. But in the reducing conditions prevailing in the interior of the converter, it has been verified that these particles are largely pyrophoric metallic iron.

It seems logical to believe that with the non-combustion of gas at the nose of the converter, the nature of these particles will remain largely unchanged in the hood and in the gas-removal pipes. Unfortunately, we have been able to take samples only from the cold parts of the installation. These collected dusts were saturated with water and had to be dried in a stove. However, we detected metallic iron (70 pct of total iron), FeO (25 pct of total iron), and a little magnetite (5 pct). More precise data are currently being collected.

It seems that the nature of these particles should facilitate dust removal, but this is a purely qualitative observation, and much more experience will be necessary before reaching definite conclusions.

The principal difficulty which comes to mind in considering the collection of converter gases without combustion is the maintenance of safety conditions. The gases are produced in a discontinuous manner, and it is necessary to avoid the formation of inflammable CO-O_2 mixtures, often under conditions which are not well known.

We will not speak of the problems posed by the subsequent use of the recovered gases since, for the moment, tests have been limited to the atmospheric combustion of dust-free gases. Problems at the beginning and the end of the collection without combustion are complex, and tests are currently in progress to study these conditions more precisely.

Another disadvantage of collection without combustion is the deposition of dusts in certain parts of the installation because the rate of gas flow is very low at times.

Conclusions

These tests on a pilot scale constitute an important and essential starting point for the industrial development of the technique for collecting refining gases from top-blown oxygen converters without combustion. An industrial installation is being built on three, 140-ton OLP converters under construction at the Dunkirk steel plant in France, and other such installations are being planned.

These techniques present the advantage of lower cost both of investment and operation for the dust collecting installation as well as the possibility of recovering a gas of considerable calorific value. They are, thus, particularly attractive for new larger oxygen steelmaking plants currently being planned in many countries.

HISTORY OF THE COKING INDUSTRY IN THE UNITED STATES

Part III

This month's installment presents the history of the eventual decline of beehive coking and the emergence of by-product coking abroad and in the United States.

by C. S. Finney and John Mitchell

The decline of the beehive coking industry was inevitable, but it had filled the needs and economy of its day. A beehive plant required neither large capital investment to construct nor an elaborate and expensive organization to run. The ovens were built near mines from which large quantities of easily-won coking coal of excellent quality could be taken, and handling and preparation costs were thus at a minimum. The beehive process undoubtedly produced fine metallurgical coke, and low yields were considered to be the price that had to be paid for a superior product. Few could have foreseen that the time would come when lack of satisfactory coking coal would force most of the beehive plants in the Connellsville district, for example, to stay idle; and if there were those like Belden who cried out against the enormous waste which was leading to exhaustion of the country's best coking coals, there were many more to whom conservation was almost the negation of what has since become popularly known as the spirit of free enterprise. As for the recovery of such by-products as tar, light oil, and ammonia compounds, throughout much of the beehive era there was little economic incentive to move away from a tried and trusted carbonization method simply to produce materials for which no great market existed anyway.

With the twentieth century came changes that were to bring an end to the predominance of beehive coking. Large new steel-producing corporations were formed whose operations were *integrated* to include not only the making and marketing of iron or steel but also the mining of coal and ore from their own properties, the quarrying of their own limestone and dolomite, and the production of coke at or near their blast furnaces. As the steel industry expanded so did the geographic center of production move westward. By 1893 it had moved from east-central to western Pennsylvania, and by 1923 was located to the north and center of Ohio. This western movement led, of course, to the utilization of the poorer quality coking coals of Illinois, Indiana and Ohio. These coals could not be carbonized to produce an acceptable metallurgical coke in the beehive oven, but could be so treated in the by-product oven.

By World War I the technological and economic limitations of the beehive oven as a coke producer were being widely recognized. After the war the number of beehive ovens in existence dropped steadily to a low of 10,816 in 1938, in which year the industry produced only some 800,000 tons of coke out of a total US production of 32.5 million tons. The demands of the second World War led to the rehabilitation of many ovens which had not been used for years, and in 1941, for the first time since 1929, beehive ovens produced more than 10 pct of the country's total coke output. Production fell off again after 1945, but the war in Korea made it necessary once more to utilize all available carbonizing capacity so that by 1951 there were 20,458 ovens with an annual coke capacity of 13.9 million tons in existence. Since that time the iron and steel industry has expanded and modernized its by-product coking facilities, and by the end of 1958 only 64 pct of the 8682 beehive ovens still left were capable of being operated.

Because beehive ovens are cheap and easy to build and can be closed down and started up with no great damage to brickwork or refractory, it is likely that they will always have a place, albeit a minor one, in the coking industry. The future role of the beehive oven would seem to be precisely that predicted forty years ago by R. S. McBride of the US Geological Survey. Writing with considerable prescience, McBride declared: "A by-product coke-oven plant requires an elaborate organization and a large investment per unit of coke produced per day. Operators of such plants cannot afford to close them down and start them up with every minor change in market conditions. It is not altogether a question whether beehive coke or by-product coke can be produced at a lower price at any particular time. Often by-product coke will be produced and sold at less than cost simply in order to maintain an organization and give some measure of financial return upon the large investment, which would otherwise

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remain entirely unproductive. As a natural consequence of this relationship of investments in the two types of plants, it may be expected that in the future most of the fluctuations in production will occur in the beehive branch of the industry. In other words, the beehive ovens will serve the purpose of standby equipment and the by-product ovens will be the normal operating agents in the supply of metallurgical fuel."

Development of by-product coking

The by-product coking industry of the United States began in 1893, but its European origins reach back to the seventeenth century. On August 19, 1681, an English patent was granted to Johann Becher and Henry Serle for "a new way of makeing pitch, and tarre out of pit coale, never before found out or used by any other". This seems to be one of the first patent references dealing with the possibility of recovering the by-products of coal carbonization. It was not until the middle of the eighteenth century, however, that the first real efforts were made to reclaim by-products. De Gensanne, a French metallurgist of the day, has described a plant which may very well have been the first by-product installation ever constructed. Built in 1766 at Sulzbach near Saarbrücken by the *Kohlenphilosoph* Johann Kaspar Staudt, the plant consisted of nine ovens which were simply muffle furnaces heated by means of coal burned on external grates. The capacity of each oven was about 1 ton of coal, and coking was carried out over a period of three days. The installation was intended to remove the sulfur from coal so that the coke might be used to make iron, but oil, tar, lampblack, and sal ammoniac were collected by Staudt. "Coal thus coked exhales not the slightest odour in burning, and it has the advantage of lasting twice as long in the fire as wood-charcoal, instead of which it may be used for all purposes without fear of the least inconvenience. This is not all; the oils and bitumens obtained in this operation almost pay the expense of it." Staudt and his ovens have the distinction of being mentioned in Goethe's autobiography *Dichtung Und Wahrheit*. As described by Goethe, who visited the plant in 1771 while a student at the University of Strasbourg, Staudt apparently had a good deal to be philosophic about. Worn and haggard, wearing a boot on one foot and a slipper on the other, he was in charge of an enterprise which was on the verge of being abandoned because (despite the glowing economic picture of the quotation above) it did not pay. In Goethe's words, "all failed together on account of the many ends in view".

Despite the granting of a patent (No. 1291 of April 30, 1781) to Sir Archibald Cochrane, Earl of Dundonald, —"that indefatigable inventor" as Professor George Lunge has described him—for "A method of extracting or making tar, pitch, essential oils, volatile alkali, mineral acids, salts, and cinders from pit-coal", by-products were not recovered on any considerable scale until the beginning of the nineteenth century and the development of the coal-gas industry.

There seems to be some doubt as to who first distilled coal gas and used it as an illuminant to any extent. Dr. Stephen Hales, Vicar of Teddington, in his *Vegetable Staticks* published in 1727 recorded that by distilling 158 grains of Newcastle coal he had been able to obtain 180 cu in. of inflammable gas, but he made no attempt to carry out further work on a larger scale. Another ecclesiastic to examine the distillation products from coal was Dr. Richard Watson, Bishop of Llandaff. In 1767, from 96 oz of Newcastle coal, Bishop Watson obtained 28 oz. of gas, 12 oz of tar, and 56 oz of what he described as "a light spongy mass, in appearance, and, indeed, in quality resembling a substance prepared from pit-coal, as an article of trade, and which is usually called coak or cinder". Of the gas which he collected, Watson wrote: "The air which issued with great violence from the retort was inflammable, not only at its first exit from the distillatory vessel, but after it had been made to pass through two high bended glass tubes and three large vessels of water". Like Hales, Dr. Watson confined his work to small-scale experiments.

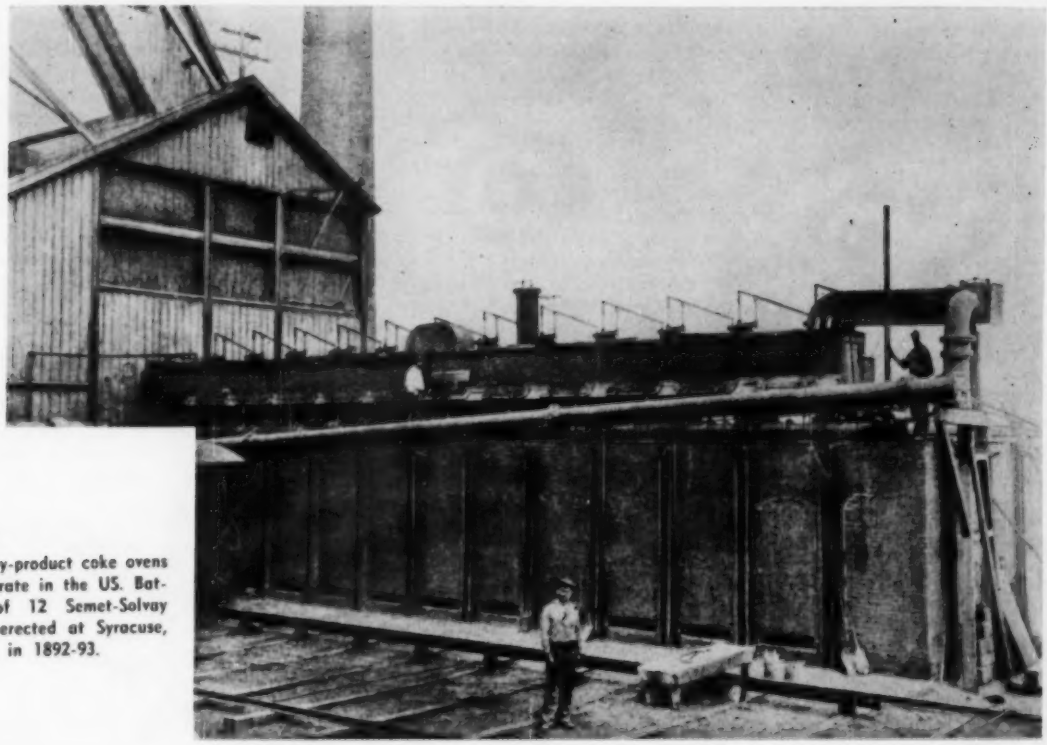
The first successful manufacture of gas and its utilization for lighting on a practical scale has been claimed for the Englishman, George Dixon; the Dutchman, Jean Pierre Minkelers; the French engineer, Phillipe Lebon; and William Murdoch of Scotland. Dixon is said to have lighted a room of his house with coal gas in 1779, while Minkelers is supposed to have used gas to light his lecture room from 1783 onwards while Professor of Philosophy at the University of Louvain. Lebon certainly obtained an illuminating gas by carbonizing sawdust, and obtained a patent in 1799 for a *most beautiful* light which he could produce with his *thermolamp*. He also experimented with coal, but only in a minor way. Whatever success the others may have had on a limited scale, it was undoubtedly Murdoch who, in conjunction with his famous collaborator Samuel Clegg, laid the foundation of the coal-gas industry. In 1792 William Murdoch, who at the time was employed by Boulton and Watt as their manager in the Duchy of Cornwall, England, lit his house and offices at Redruth, Cornwall, with coal-gas generated in an iron retort in his backyard. He also carried bladders of gas to light himself home at night. In 1798 Murdoch built an apparatus at the Soho works (Birmingham) of Boulton and Watt, for making, storing, and cleaning gas, which was used to light parts of the factory. And in 1802, to celebrate the Peace of Amiens, two *Bengal Lights* were put up at the works as a public display of the new gas-lighting.

World's first gas company

In 1812, largely due to the efforts of that remarkable character, Frederick A. Winsor, the world's first

Coking Industry During the 20th Century

	No. of Ovens In Existence		Production, Million Net Tons			
				By-Product		
Year	Beehive	By-Product	Beehive	Quantity	Percentage of Total	Total
1900	57,390	1085	19.4	1.1	5.2	20.5
1905	84,405	3103	28.8	3.4	10.7	32.2
1910	100,362	4078	34.6	7.1	17.1	41.7
1915	93,110	6268	27.5	14.1	33.8	41.6
1920	75,298	10,881	20.5	30.8	60.0	51.3
1925	57,587	11,290	11.4	39.9	77.9	51.3
1930	33,907	12,831	2.8	45.2	94.2	48.0
1935	13,674	12,880	0.9	34.2	97.4	35.1
1940	15,150	12,734	3.1	54.0	94.6	57.1
1945	12,179	14,510	5.2	62.1	92.3	67.3
1950	17,708	14,982	5.8	66.9	92.0	72.7
1955	10,104	16,039	1.7	73.6	97.7	75.3
1956	9,549	15,923	2.5	72.0	96.0	74.5
1957	9,519	15,897	2.1	73.9	97.2	76.0
1958	8,682	16,244	0.6	53.0	98.9	53.6
1959	7,448	15,963	1.1	54.6	98.0	55.7



First by-product coke ovens to operate in the US. Battery of 12 Semet-Solvay ovens erected at Syracuse, N. Y., in 1892-93.

gas company, the Gas Light and Coke Co. of London, was chartered. Born Winzer (or Winzler) in Zhaim, Moravia, he was a dauntless, if rash and flamboyant advocate of the budding industry. To further his vision of a public gas supply, he did not spare either his own energies or the pockets of any who would listen to him. Neither did he spare their sensibilities, if the following jingle attributed to him can be taken as typical of his publicity methods:

"Most mortals on earth with smoke live in strife
And many a beauty is smothered alive.
Great London itself, th' empor'um of the world
In clouds of black smoke is constantly furl'd.
Smoke begot chimneys, chimneys beget smoke,
Soot, fires, and filth all prevented by coke."

Poet, experimentalist, entrepreneur, Winsor was many things to many men. He died in France in 1830, very little the richer for his pioneering. Although never a modest person, it is likely that even Winsor had no idea that his contributions to the founding of an industry would bring him such fame. The dignified words of Samuel Clegg's son in 1841 might well have formed his obituary. "He was not cast in the same mould as Mr. Murdoch, and it is therefore unfair to measure him, as some have done, by such a standard. One was a philosophical investigator—the other an impetuous schemer. Each had his own sphere of action; each was great in his own way; each deserves to be, and will be, kept in remembrance."

The establishment of the Gas Light and Coke Co. in 1812 was rapidly followed by the building of public gas-works in Paris in 1815, in Baltimore in 1816, Boston in 1822, New York in 1825, and Berlin in 1826. The liquor and tar which were produced during the manufacture of city gas were at first a source of much trouble and embarrassment to the gas companies. They were of no commercial value, a nuisance to store, and could not be indiscriminately dumped. At the Glasgow gas-works attempts were made to use tar, for example, in the heating of the retorts, while in Paris it was sold in small amounts for medicinal purposes. In 1845, however, A. W. Hoffmann recognized and proved the presence of benzene in coal tar, and the method of obtaining it in quantity from tar was developed in Hoffmann's laboratory by his pupil, Charles Mansfield. In 1856, W. H. Perkin discovered mauve, the first of the aniline colors, and thus founded the coal-tar-dye industry. Perkin was trying to make quinine from aniline. Instead of quinine he was left with a black powder. The latter, when extracted with *methylated spirits of wine* gave a solution which "when distilled left the mauve as a fusible bronze-coloured mass". The presence of napthalene in coal-tar was discovered by both Garden and Brande in 1819, and investigated in detail by Lawrent in 1832. In the same year Dumas proved anthracene to be a constituent of tar, and in 1869 Graebe and Liebermann synthesized the dyestuff alizarin from the compound. Coincident with these developments was the work of Liebig, the great German chemist, and Lawes and Gilbert, founders of the Rothamsted Experimental Station in England, upon plant nutrition. This led to a wider understanding of the value of artificial fertilizers in assisting crop growth, with the result that the ammoniacal liquor which in earlier times had been such a nuisance to the gas industry could henceforth be profitably utilized in the production of ammonium sulfate.

Early oven design

The progress of the city gas industry and the development of markets for the by-products must have been watched with considerable interest by the

manufacturers of metallurgical coke. However, neither in Europe nor in America did the coking industry at first show much enthusiasm for modifying its operations to allow by-product recovery. This indifference may have stemmed from the fact that for metallurgical purposes the quality of gas-works coke was much inferior to that obtained from the beehive oven. The inference drawn was that a good blast furnace coke could not be made in ovens from which by-products were recovered, and this conclusion seemed to be sustained by the poor coke produced from the new, closed, retort-type ovens that were being developed on the continent by such men as Knab, Coppée, Appolt, Carvés, and Francois-Rexroth. In the first designs no attempt was made to recover ammonia or tar, but the gas was utilized to heat the ovens instead of being wasted. Knab, in 1856, at Commentry, Dept of Allier, France, built a group of ovens which were narrow, vertical chambers 23 ft long, 6 ft, 6¾ in. high, and 3 ft, 3¾ in. wide. The combustion flues were located below the oven base. The quality of the coke was not impressive, but the yield, at 63 pct of the coal charged, was quite good. In 1862 Knab was joined at Commentry by Carvés, who greatly improved the heating system of the Knab oven by using side flues in addition to the original bottom flues. Better temperature distribution and faster carbonization were thus obtained. Carvés also extracted tar and ammoniacal liquor from the gas before returning it to the oven, an exhauster being used to take it off from the ovens and pump it through the by-product recovery train. The Knab-Carvés ovens gave the following yields: Large coke—70.00 pct; Breeze—1.50 pct; Dust—2.50 pct; Graphite —0.50 pct; Tar—4.00 pct; Ammoniacal liquor—9.00 pct; Gas—10.58 pct; Losses—1.92 pct. In 1881 Henry Simon of Manchester, England, added a recuperator to the Carvés oven so that the air required for combustion in the side-wall flues could be preheated by the waste gases. Simon-Carvés ovens were built at Bear Park, Durham, in 1883, and achieved a coking time of 48 hr.

The Appolt oven was another early design in which by-product recovery was limited to use of the gas for heating the oven. This was a vertical-type oven consisting of a series of upright, rectangular retorts enclosed in a large, vertical combustion chamber. The retorts were wider (4 ft x 1 ft 6 in.) at the base than at the top (3 ft 8 in. x 13 in.) to facilitate coke discharge, and were 13 ft high. Each retort held about 13 tons of coal, and the coking time was 24 hr. The Appolt oven was expensive to build and maintain, and coke quality was variable.

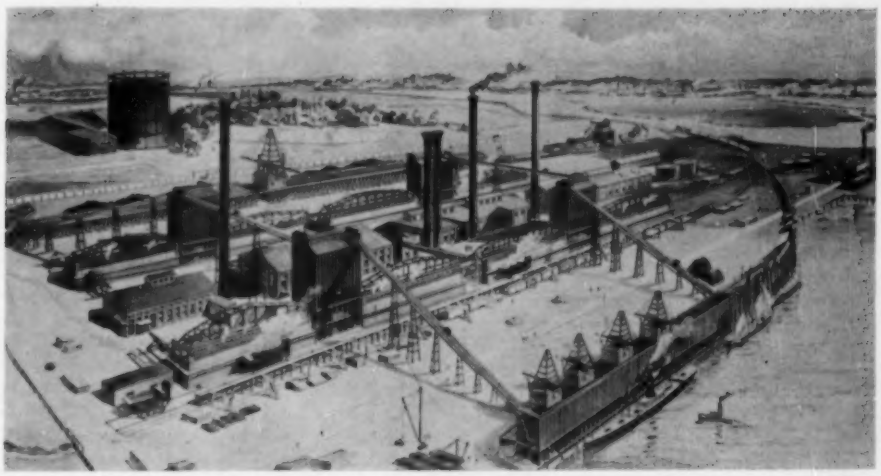
Retail delivery of Otto Coke in 1903.

The ovens designed by Francois-Rexroth were, like the Knab and Simon-Carvés ovens, of the horizontal type. Unlike the latter, however, they incorporated vertical instead of horizontal heating flues, and may thus be regarded as the prototype of the modern by-product oven. Some 26 ft long, 5 ft high, and about 35 in. in width, the Francois-Rexroth oven had a taper of 2 in. Gas and air were supplied to the vertical flues at various points below the top of the oven, and the waste gases were subsequently discharged to the stack by means of bottom flues underneath the oven. Three tons of coal per oven could be carbonized in 48 hr.

In 1861 the Francois-Rexroth oven was modified and improved by E. Coppée of Belgium. Coppée combined the rather high, narrow coking chambers used previously by Smet, with the vertical heating flues introduced by Francois-Rexroth, the result being an oven 30 ft in length, 15 to 18 in. wide, and 4 to 5 ft high. Each of the 28 vertical combustion flues was provided with a separate air control-damper. Heating could thus be more accurately controlled, and refractory life was much improved compared to earlier ovens. The first Coppée ovens to be built in Germany were constructed in the Ruhr by Dr. C. Otto in 1876. They were 24 in. wide, 68 in. high, and about 30 ft long; the carbonizing time was 48 hr. The length of the later Coppée ovens was increased to 33 ft, the height of 68 in., and the width of 24 in. being retained. The number of combustion flues was increased from 28 to 32. A 72 pct coke yield could be obtained, and oven capacity was 7 to 8 tons of coal. The sensible heat of the waste gases was recovered by means of waste heat boilers.

Although by 1881 considerable progress in the recovery of by-products from coke ovens had been made in France, little work on a commercial scale had been done in Germany. The attempt was made in 1881 by Albert Hüssener of Essen, who built 50 coke ovens at Gelsenkirchen of a type similar to those used by Knab and Carvés. About 15 pct of the coke produced was used to heat the ovens, and the principles used in gas-works practice were employed to recover by-products. Designed to make blast furnace coke from a high-volatile gas coal, the ovens were at first a complete failure. When charged with a lower volatile coal, however, good metallurgical coke was obtained, together with a favorable yield of satisfactory by-products. Thus encouraged, Hüssener put up a second battery of 50 ovens in which improved combustion arrangements allowed the use of coke for heating purposes to be dispensed with, and a small amount of surplus gas to be obtained. Hüssener's success did much to correct the belief that acceptable blast furnace coke could not be made in by-product ovens.

In 1882 Dr. Th. von Bauer of Germany recommended the use of the Siemens regenerative principle for coke-oven operation, and in 1883 Gustav Hoffman patented the idea. The German patent (No. 18,795) was bought by Dr. C. Otto and Co., who applied it to the Otto-Coppée oven, and the first Otto-Hoffmann type plant was built near Wanne in 1883. Improved ovens of this type rapidly gained popularity in Germany, and by 1894 more than 1200 of them had been built on the Continent. They produced good metallurgical coke at yields of 70 pct and better, and considerable quantities of tar and ammonia products were obtained. At the time of Otto's death in 1897 more than 10,000 Otto



Otto-Hoffmann ovens at the Everett Coke Plant in Massachusetts. Circa 1898.

oven had been constructed in Germany alone. Many of these were not by-product ovens, but in that particular year some 7 million gallons of tar, 400,000 gallons of benzole, and 14,000 tons of ammonia products were produced in plants operated by Dr. C. Otto and Co. Plainly the by-product coking industry of continental Europe was now firmly established.

By-Product coke ovens in the US

Blessed with abundant quantities of such celebrated coking coals as those of Connellsville, Durham, and South Wales, American and British coke makers had not been forced to develop (and were little inclined to adopt) the coking methods required to treat the poorer coals of Belgium, France or Germany. Furthermore, in both the United States and in Britain, the superiority of beehive coke was accepted as an article of faith long after the iron masters of Europe had overcome their prejudice against coke made in the by-product oven. In October of 1891, in a paper given at the Franklin Institute of Philadelphia, Dr. Bruno Terne declared that "If you will visit our coal region today, you will find the nightly sky illumined from the fires of the coke ovens, and every one of the brilliant fires bears testimony that we are wasting the richness of our land in order to pay the wiser European coke manufacturer, who saves his ammonia and sends it to us in the form of sulfate of ammonia; and who also saves his tar, which, after passing through the complex processes of modern organic chemistry, reaches our shores in the form of aniline dyes, saccharin, nitrobenzol, etc.

"As far back as 1768, tar had been produced as a by-product of the coke industry by a chemical process at Fishbach, in the coal district of Saarbrücken on the Rhineland. (Authors' note: this seems to be a reference to the work of *Kohlenphilosoph* Staudt.)

"The general opinion of the consumer there was then, and most likely will be here at the present time, that the coke produced will be of inferior quality. Against this opinion of the practical coke men, it has always been held by technical chemists, that the process can be so conducted as to yield all the by-product and still make a first class coke."

In England, even as late as 1893, no less a person than Sir Isaac Lowthian Bell felt able to write of the by-product oven that "My own firm has spent large sums in pursuit of a plan of obtaining ammonia, etc., and the firm of Messrs. Pease and Company are continuing the process with perfect success as regards the by-products, but they, or their customers, find, as we found, the coke not so suitable for blast-furnace work as that burnt in the old-fashioned beehive oven".

The first by-product coking plant to be constructed in the United States was associated with the chemical industry. In 1882 the first ammonia-soda plant for the production of soda ash had been built at Syracuse, N. Y. by the Solvay Process Co., founded by Ernest Solvay of Belgium. The son of a salt manufacturer, Solvay had observed the reaction of ammonium bicarbonate on brine in 1861, and had subsequently established a successful process for the production of sodium carbonate. This process involved the use of ammoniacal liquor and coke. The former was the source of ammonia, and the coke was employed to obtain carbon dioxide by burning limestone in vertical kilns. In association with Semet (a relative who was employed at the Brussels Gas Works), Ernest Solvay had developed the Semet-Solvay coke oven to provide the necessary raw materials, and in 1892 the erection of 12 of these ovens, the first by-product ovens in America, was commenced at Syracuse.

Like the Carvés oven, the Semet-Solvay oven was of the horizontal-flue type, but each oven was designed with its own individual heating flues which were separated from those of the adjoining oven by a robust firebrick wall. The Syracuse ovens were 30 ft long, 16½ in. in width, and 5½ ft in height. A charge of 4.4 tons of coal could be carbonized in 24 hr. The cost of the Syracuse installation has been given as $88,014.

Because the by-product train installed was large enough to handle the output from 25 ovens, the total cost per oven was rather high at $7334. During 1893 the 12 ovens at Syracuse produced 12,850 tons of coke.

The success of the Solvay Process Co.'s pioneering venture did much to establish the respectability of by-product coking in the United States, and the day for which the conservationists such as Belden had hoped, was rapidly arriving. It was not long before the suppliers of capital came to realize that here was a promising field for investment, and coke users to appreciate that the unattractive, dull, grayish-black coke that they had

scorned to accept could, in fact, compete with the lustrous, silvery-gray, beehive product as a metallurgical fuel. In 1895 two more batteries, each containing 25 Semet-Solvay ovens, were constructed for the American Manganese Manufacturing Co. at Dunbar, Pa., followed by 90 ovens at Ensley, Ala., for the Tennessee Coal, Iron and Railroad Co. in 1898, and a further 30 ovens at the same place in 1899. During 1898 and 1899 90 Semet-Solvay ovens were also constructed near Wheeling, W. Va., for the National Tube Co. The capacity of the later ovens was enlarged from the original 4.4 tons to 7 to 9 tons by increasing the length to 35 ft and raising the height to as much as 9 ft. The standard width of 16½ in. was maintained.

Naturally the Semet-Solvay Co. (a subsidiary of the Solvay Process Co.) had competitors in the business of building by-product ovens. Their success in Europe with the vertical-flue Otto-Hoffmann oven had led Dr. C. Otto and Co. to consider whether they might not enter the American market, and Dr. F. Schniewind was commissioned to investigate the possibilities. As a result of Schniewind's activities, the Otto Coke and Chemical Co. was formed, and this was rapidly enlarged into the United Coke and Gas Co. with W. L. Elkins, Jr. of Philadelphia as president, and Schniewind as vice-president. Elkins and Schniewind managed to interest the Cambria Steel Co. of Johnstown, Pa. in the Otto-Hoffmann system of carbonization, and in the summer of 1893 the steel company sent John Fulton to Germany to investigate whether Connellsville coal might be successfully coked in such a plant. Fulton reported that as a result of oven tests carried out on some 18 tons of Connellsville coal, a 71 pct yield of large coke was obtained which was of excellent metallurgical quality. A contract was accordingly signed for the construction of two batteries of 30 ovens each, together with a full by-product recovery system, and during 1894 work on the first by-product plant to be erected for the specific purpose of supplying blast furnace coke was begun at Johnstown.

The next move by the enterprising managers of the United Coke and Chemical Co. was to attract the attention of the iron and steel industry at Pittsburgh. A site at Glassport, near McKeesport, was therefore selected as a suitable location for the construction of by-product ovens which could carbonize the readily available Pittsburgh seam coal, and from which the blast furnaces of the area could be supplied with coke. In 1897 120 ovens and an associated by-product recovery plant were built for operation by the Pittsburgh Coke and Gas Co. The ovens were arranged in four batteries; they were 33 ft long and 6 ft high, had a taper of 22 to 19 in., and held about 6 tons of coal. A laboratory was provided, and provision was also made for oven tests on carload lots of coal. Gas was supplied to McKeesport.

The largest single installation of by-product ovens during the ebb of the nineteenth century was the contract for eight batteries of 50 Otto-Hoffmann ovens each at Everett (near Boston), Mass. for the New England Gas and Coke Co. The latter company was organized in 1897 by Henry M. Whitney. During the early 1890's Whitney had become associated with the local gas utility business in Boston, and he had also developed interests in the Dominion coal fields at Cape Breton, Nova Scotia, which had been discovered in 1896. The coal from Cape Breton was a high-volatile coking coal which could be landed in Boston at low cost, and the construction of a by-product coking plant gave an expanding Boston the gas it needed and assured Nova Scotia of a market for its coal. Work was begun in 1898 on 299 acres of land in the Everett and Chelsea districts, and production commenced in 1899. The ovens were almost identical with those of the Glassport installation, and incorporated the *rich and poor gas system* which Schniewind had developed for the latter. Coke production was 1400 long tpd, half of which was supplied to such railroads as the Boston and Maine, and the New Haven and Hartford, as a locomotive fuel. Of the remainder, 25 pct was sold to steam generating plants, and 25 pct was marketed for domestic purposes. Often sold in half-bushel paper bags through grocery stores, etc., the domestic coke was publicized in the following terms: "Otto coke is the new domestic coke, better than hard coal, and costs about $2.00 less per ton. It's made from coal by burning off smoke and dirt . . . all the things you don't want . . . and leaving a firm, smokeless fuel" The housewives of Boston also discovered the *Otto coke* to have a further property not possessed by hard coal; it gave rise to considerable clinkering troubles. The gas produced at the Everett plant was sold to various local gas companies. The first contract called for the delivery of 12 cp unpurified gas at a price of $0.14 per mcf, but after four or five years the price had to be raised to $0.23 per mcf and by 1917 it was up to $0.295 per mcf. The candlepower of the gas was also increased from 12 to 16, and subsequently to 18.

As the following tabulation shows, by 1902 (that is, 10 years after construction was commenced on the Semet-Solvay ovens at Syracuse) the by-product coking industry had expended tremendously.

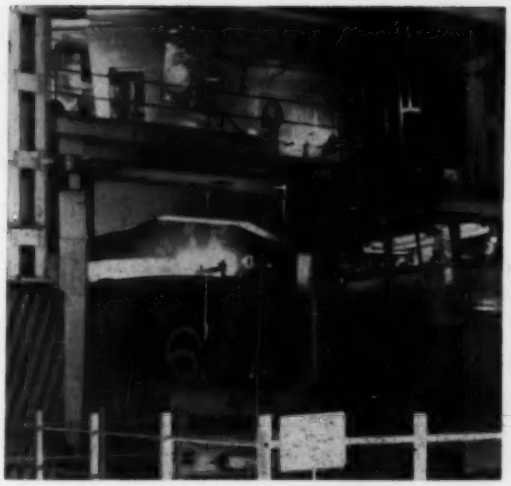
The First Ten Years of By-Product Coking

Year	Ovens in Existence at End of Year	Ovens Being Built	Production Net Tons
1892	—	12	—
1893	12	—	12,850
1894	12	60	16,500
1895	72	60	18,521
1896	160	120	83,038
1897	280	240	261,912
1898	516	500	294,445
1899	1,016	65	906,534
1900	1,081	1,096	1,075,727
1901	1,161	1,533	1,179,900
1902	1,669	1,346	1,403,588

The figure of 1669 for ovens in existence at the end of 1902 has been taken from the Bureau of Mines Circular 7996, *Coke Plants in the United States on December 31, 1959*. John Fulton in his book *Coke* published in 1905 quotes a figure of 1663, however, which is in agreement with that used for many years in earlier publications by the Bureau of Mines. Included in this total of 1663 were 525 Semet-Solvay, 1067 Otto-Hoffmann, 15 Schniewind, and 56 Newton Chambers ovens. Of the 1346 ovens under construction, there were 210 Semet-Solvay, 664 Otto-Hoffmann, 412 Schniewind, and 60 Retort Coke Co. ovens. The Schniewind oven was a modification of the Otto-Hoffmann oven. Designed to allow accurate and uniform distribution of fuel gas to the combustion chambers, it had a further advantage in that the regenerators were built independent of the oven structure and could not therefore affect the latter by expansion.

(To be continued)

AMERICA'S FIRST D-H UNIT



Crucible Steel Co. of America recently demonstrated its new D-H vacuum degassing unit by processing a 170-ton heat of open-hearth steel at its Midland, Pa. works. The unit is the first of its type in the US.

The world's largest D-H degassing unit—the only one of its kind in the US—was recently demonstrated by the Crucible Steel Co. of America at its Midland, Pa., works. The D-H process, developed by the Dortmund-Hoerder Huettenunion of Dortmund, Germany (see May 1960 issue of JOURNAL OF METALS, p. 398), removes impurities from molten steel by exposing it to the pressure of an evacuated vessel.

Prior to the degassing operation, a ladle of steel is placed on a movable car and positioned under the treatment vessel. The pear-shaped treatment vessel contains a heating element which maintains the temperature at 2700° F under a pressure of about 0.001 atm. The vessel is supported on four piston-like legs and can be raised or lowered with three 75 hp motors.

At the start of the treatment, the vessel is lowered until its protruding refractory snorkel penetrates the metal in the ladle to a predetermined depth. A vacuum is then drawn in the treating vessel, and the degassing operation begins. As the vessel moves from the highest to the lowest position, the metal flows through the snorkel into the degassing chamber, and as the vessel reverts back to its original position, the degassed metal flows back into the ladle. The motion of the molten metal is held in phase with the moving vessel by a calculated adjustment of the vessel speed, stroke, and dwell.

With each completed cycle, approximately one-tenth of the total weight of the metal in the ladle is treated and recirculated. About 32 cycles are required to degas effectively a 170-ton heat before alloying. Alloy additions are made from the vacuum-tight hoppers located at the top of the vessel.

The final phase of the treatment consists of six mixing cycles to promote homogeneity. At the end of the degassing operation, the metal is adjusted to the correct teeming temperature, and transferred to the teeming area where the heat is cast into 12-ton ingots.

The flexibility and the low temperature loss of the process permit a wide variety of treatments to achieve various objectives. Composition can be brought under unusually close control by the addition of small increments of alloys under vacuum conditions. Temperatures can be controlled by thorough mixing, control of the heater rod during treatment, additions of various alloys, and by adjustment of the treatment or holding time.

To date some 100 heats have been run in the unit at Crucible, and the following grades of steel have been treated; 1020, 1040-46, 1085-95, 4130, 4142, 4320, 4340, 5140-5160, 8620, 8640-45, 51100, 52100, and H-11. Maximum alloy addition has exceeded 2 pct with no associated problems, and it appears that two-to-three times this quanity could be added.

Recovery of the alloy additions has been very favorable thus far. This is best illustrated by silicon recovery. A recovery of 100 pct Si has been obtained on most heats. Chromium recovery has been averaging 97 pct, and manganese from 80 to 100 pct for small additions, and approximately 95 pct for larger additions. It is interesting to note that the chromium and managanese losses are due to volatilization rather than oxidation as evidenced by the high silicon recovery.

In addition to the high alloy recoveries, the process permits better chemistry control than the usual open hearth practice, produces steels with consistently fine and normal grain sizes, removes flake, and shows significant improvement in microcleanliness. Gas contents of the treated steels have been measured; oxygen reductions have ranged from 55 to 90 pct, and steels high in nitrogen, lose about 25 to 33 pct of their nitrogen content during treatment.

Although the quality level produced by the D-H process is not quite equivalent to that of vacuum melted products, the tonnage that can be treated in a relatively short time span should definitely have an impact on the steel industry. Crucible officials hope that, as the capabilities of the unit are developed, it will open a whole new field of possibilities for producing new grades of steel and steels that are now confined to rather difficult specialized electric furnace practices. *E.J. Fitzgerald*

FORGING UNCLAD BERYLLIUM

A forging development program has demonstrated that hot-pressed beryllium metal may be bare forged successfully into certain configurations. Technical details of the required procedures are presented, and the results are evaluated.

by J. P. Denny and J. D. McKeogh

Conventional beryllium forgings have not been produced in quantity in the past, and most prior beryllium forging work has employed a steel jacket which has supported the beryllium during forging. Steel jackets approximately ½ in. thick have been used by some investigators to provide such support, thereby minimizing tensile stresses and preventing rupture. Steel jackets also protect the beryllium against excessive oxidation and minimize toxic effects at elevated temperatures.

It is apparent however that the forging of unclad beryllium presents decided advantages, from both a cost and mechanical property standpoint. A development program of 16 trial forgings was accordingly undertaken, the objective of which was to produce a specific forging as described in the following.

Procedure

The designed forging consisted of a center hub approximately 1½ in. high with a circumferential web around the hub. Provision was made for expulsion of flash at a nominal diameter of 3¾ in., and two sizes of cylindrical forging blanks were selected for study, respectively 3 in. and 3¾ in. diam. Figs. 1, 2, and 3 illustrate the configuration of the final forging. The design required material flow during forging from the web to the hub, and laterally from the blank to the part wall.

Beryllium Corp. HP-20 material was used for all starting blanks. The minimum mechanical properties of HP-20 are 40,000 psi ultimate tensile strength, 30,000 psi yield strength, and 1 pct elongation. This material is a hot-pressed grade of beryllium prepared from −200 mesh powder, and conforms to the following chemical specification: Be assay—98.0 pct min; BeO—2.0 pct max; C—0.15 pct max; Fe—0.20 pct max; Al—0.18 pct max; Si—0.08 pct max; Mg—0.08 pct max; and others—0.04 pct max each.

Beryllium preheat temperatures of 800°F and 1400°F were selected for study inasmuch as these temperatures correspond to reported ductility peaks in hot-pressed beryllium test specimens[1]. Temperatures in the range 1300° to 2050°F are reported[2] to have no effect on the forgeability of hot-pressed beryllium provided that sufficient support is afforded the beryllium, and the heating of beryllium in air at temperatures above 1472°F is regarded[2] as potentially hazardous. Beryllium is not severely oxidized when heated at 1400°F for reasonable periods of time.

Forging tests, conducted at Wyman-Gordon Co., utilized a 660-ton hydraulic press. The dies, shown in Fig. 4, were preheated to a temperature of approximately 800°F, and the press stroke was 72 in. per min. Safety precautions were taken which included placing an Aerotec unit with absolute filter in the vicinity of the press. Any fumes coming from the heated pieces were exhausted through the Aerotec unit by means of a steel funnel-shaped hood and flexible hosing. The hood was kept in close proximity to heated pieces during all part-transfer operations. Subsequent results of air monitoring operations showed that the air counts did not exceed tolerances prescribed by the Atomic Energy Commission. No count was higher than one microgram of beryllium per cu m of air.

A specially prepared solid lubricant was used in 13 cases, and a ceramic coating was used for lubrication in three cases. Fourteen pieces were etched in a phosphoric acid-sulfuric acid-chromic oxide solution prior to forging, and two pieces were forged in the as-machined condition. One piece was air cooled whereas the balance of the pieces were slowly cooled in vermiculite insulation. Some of the pieces were forged twice. Variation of the above procedures permitted insight into the importance of these variables.

Results

All forged parts were subjected to dimensional and fluorescent die-penetrant inspection, and metallographic and mechanical property studies were performed on selected parts. Four pieces were found to be completely satisfactory, and these define the optimum forging parameters as developed in the investigation.

Mechanical properties were determined on bars cut transversely across a final forging and were as

Table I. Mechanical Properties of Original Hot-Pressed Metal vs Forged Part

	Ultimate Tensile Strength, psi	Yield Strength 0.2 pct offset, psi	Elongation, pct
Hot-pressed	48,100	30,700	4.3
Forged	66,400	50,700	3.0
Forged	67,300	49,100	5.1

J. P. DENNY is with the Beryllium Corp., Reading, Pa. and J. D. McKEOGH is with the Wyman-Gordon Co., North Grafton, Mass.

shown in Table I. These values represent a significant improvement over the original hot-pressed tensile and yield strengths.

One of the forgings was sectioned, milled, and etched to study forging flow lines. Grains immediately adjacent to the worked surface were found to have a length-to-diameter ratio of approximately five, and the centrally located grains were equiaxed. The material was sound throughout except that there was minor spalling along the hub edge and web, which did not interfere with the desired finished part. Polarized light at 75 magnifications was required to reveal the forging flow lines. An additional piece was surface machined, and fluorescent die-penetrant studies revealed no surface imperfections.

Conclusions

The principal conclusions may be summarized as follows:

1) A beryllium blank preheat temperature of 1400°F is definitely superior to 800°F. Both pieces forged with 800°F preheat were cracked during the operation, and the center hub was not properly formed. A preheat temperature of 1400°F, on the other hand, minimized cracking and provided increased flow along the center hub;

2) The starting blank size is critical in a particular forging. In the present study, all four satisfactory pieces employed the 3 in. diam starting blank;

3) Flash trimming followed by a second forging strike at 1400°F was demonstrated to increase the height of the center hub from 0.07 to 0.37 in., dependent upon forging conditions;

4) A special solid lubricant proved to be superior to the ceramic coating employed, from a surface finish standpoint. Satisfactory parts were made by both techniques, however;

5) Limited evidence suggests that the parts may be air cooled after forging, and that it is not necessary to etch the blanks prior to forging. These items require tests on more pieces than were available and need further confirmation; and

6) There is a correlation between die temperature and hub filling characteristics, with the higher die temperatures (800° to 900°F) providing best results.

The bare forging of beryllium, while not a panacea for all forming problems, has been shown to be definitely feasible. It is expected that the present dynamic growth of the beryllium industry will be accomplished by increasing utilization of this technique.

References

[1] D. W. White and J. E. Burke: The Metal Beryllium, *ASM*, Cleveland, Ohio, 1955, p. 318.

[2] Ladish Co.: Beryllium Forging Program, Interim Eng Report no. 2, Aug 8, 1958 to Feb 8, 1959, US AF33(600)36795.

[3] F. J. Viles: Review of Control Problems in Operations Using Various Beryllium Compounds, *AMA* Archives of Industrial Health, Beryllium Disease and Its Control, vol. 19, no. 2, Feb 1959.

Fig. 1

Fig. 2

Fig. 3 (Above)

Fig. 4 (Below)

Top to Bottom, Fig. 1—Stub shaft forged with 800°F preheat. Note cracked wall and inadequate hub filling. Fig. 2—Forged with 1400°F preheat, ceramic coat lubrication. Rough surface finish on dimensionally sound part. Fig. 3— Forged with 1400°F preheat, solid lubrication. Satisfactory part with minor surface imperfections. Fig. 4—Die inserts and aluminum development forging.

LACLEDE'S VILLAGE AND THE 1961 ANNUAL MEETING

The McNaughtons (left), the Gillsons (right)

No, it wasn't one of the world's largest breweries, nor a famed zoological garden which brought 2312 metallurgists, petroleum engineers, geologists, and mining engineers across the prairies to the confluence of this Mississippi and the Missouri rivers—to what was originally known as Laclede's village and is now the mammoth, sprawling, metropolitan giant known as St. Louis. No, it was the 1961 AIME Annual Meeting.

While perhaps not the largest meeting ever, it was a highly fruitful one with numerous important papers and symposia presented. During the course of the next year, we shall try to include as many of these papers as possible in the JOURNAL OF METALS, and many others will appear in The Transactions of The Metallurgical Society.

At this point we shall only skim over some of the major functions and present a picture story of the main events of the 1961 AIME Annual Meeting.

Howe Memorial Lecture

For The Metallurgical Society, high points of the Annual Meeting included the three divisional lectures, which are being published in full in Transactions.

The Iron and Steel Division, presented the Howe Memorial Lecture on Tuesday morning the 28th of February. The lecturer was Lawrence S. Darken, associate director of the Edgar C. Bain Laboratory for Fundamental Research, U.S. Steel Corp., Monroeville, Pa. His subject was the *Role of Chemistry in Metallurgical Research*.

Dr. Darken discussed the role of physical chemistry in the understanding of metallurgical phenomena, especially in the high temperature field and in the area related to iron and steelmaking.

He said in part: "Fuller understanding of metallurgical problems, as of all problems, and the consequent evolution result from new insights into interrelations between newly found or previously known phenomena or ideas. The term *coupling* seems to express adequately this fruitful process of bringing together two or more independently developed concepts, ideas, effects or areas to form a new one. Thus, metallurgy, which may be regarded as a coupling of chemistry, physics, and engineering, has been an interdisciplinary science longer than that term has been in common use."

The Howe Lecturer remarked further: "The individual scientist in industry, to be productive, needs considerable freedom, whereas industrial interest may appear to lie in certain rather well defined problems. In view of the unpredictability of the results of fundamental research, sometimes called the serendipity principle, one never can tell in advance when problems will be solved by what type of research. Certainly, a century ago it was not forseen that the problems of disasters at sea would be resolved largely by research on electromagnetic phenomena—radio and radar.

"The problem of this coupling of fundamental research and industrial research is indeed a delicate one which is usually handled with some measure of success by a selection of certain broad areas for investigation, thus minimizing restrictions of the freedom of the individual and bringing in a degree of unity to the research effort as a whole. Closely related is the coupling of applied research both to fundamental research and to industry.

"The coupling of education to research and to society as a whole is a matter currently receiving a great deal of attention, with repercussions on the entire educational system. As metallurgists, we often hear pondered the question of which way to head—solid state physics, process metallurgy, basic science, thermodynamics, physical chemistry, engineering. I think the answer is that there is no way, that we need all ways, but since man is so human, no one individual or a small group, as in a department, can

encompass all in depth; hence we have and need all sorts of metallurgists and all degrees of emphasis."

Institute of Metals Lecture

Wednesday morning was the period set aside for the Institute of Metals Lecture, given by David Turnbull of General Electric Co., Schenectady, N. Y. Dr. Turnbull spoke on *The Liquid State and the Liquid-Solid Transition.*

In discussing his subject, Dr. Turnbull pointed out that, "There have been two principal approaches to the theory of liquids. One is intuitive and modelistic and has led to the present free volume theory. This theory is not rigorous, but it has provided valuable insights on liquid behavior as is shown by the successful correlations which have arisen from it. The other approach is the method of distribution functions. It is beset by great mathematical difficulties but has the potentiality of leading to a rigorous theory. Recently there have been important advances in the techniques for evaluating the distribution function. Liquid state models often have been patterned largely after crystal models since liquids and crystals are quite similar to each other in certain aspects of their behavior. However, some of the important properties of simple liquids, e.g. molecular transport and structure, are well represented, at least qualitatively, by an equivalent system of hard unattracting spheres. This indicates that a dense gas is perhaps a better guide than the crystal for a liquid model. The liquid state theoretical developments have been directed so far toward the understanding of liquids with the simplest molecular constitutions. Metallic liquids exhibit certain unique properties not adequately accounted for by any of the simple models. A liquid may solidify in two ways: either discontinuously to a crystalline solid or continuously to an amorphous solid of glass. According to the free volume theory all liquids would form glasses, when sufficiently undercooled, save for the intervention of crystallization. This viewpoint is supported by the experience that glass formation occurs not only in molecularly complex systems but also in metallic and ionic systems and in systems of simple molecules bound by van der Waals forces alone. The thermodynamics and kinetics of the liquid-crystal transition in pure substances are also reviewed."

Extractive Metallurgy Lecture

The Third Extractive Metallurgy Division Lecture was presented by Antoine Gaudin, Richards Professor of Minerals Engineering at Massachusetts Institute of Technology. Title of the lecture was *Separation Engineering on the Moon.*

Taking into consideration the moon's essential lack of an atmosphere and related factors, Prof. Gaudin suggested "that metallurgical processing on the moon's surface, unless in a closed container, would have to be done in a vacuum some thousands of times better than the best vacuum available here."

Proceeding to other difficulties, Prof. Gaudin said: "The moon thus must be bereft not only of oxygen but also of fuels. All rocks must have had a plutonic or volcanic or planetisimal origin. There are no limestones, no sandstones, no shales, no clays. And, of course, no coal, no oil, no natural gas. Since, also, there are no waterfalls, no winds, no water currents, all the customary and many of the unusual ways of making electricity are barred. Fuels are used in metallurgical operations as a source of heat and as reducing agents."

DIVISION LECTURERS

Howe Memorial Lecturer, Lawrence S. Darken

Institute of Metals Lecturer, David Turnbull

Extractive Metallurgy Lecturer, Antoine Gaudin

Prof. Gaudin said the source-of-heat function provided by fossil fuels can be replaced by solar heat with mirrors for concentration of solar radiation. "But," he warned, "there is no substitute for the reduction action of fossil fuels, unless other agents are available. Among these would be igneous or volcanic graphite and volcanic sulfur. But the existence of such reduced compounds is now entirely problematical. Another source of reducing agents might be sought in components of hydrogen in the solar wind."

He went on to say: "Unfortunate as it is, we probably would find it necessary to transport from earth our reducing agents rather than try to make them on the moon! Accordingly we would select the most concentrated reducing agent, probably hydrogen, a hydrocarbon, borocarbon, or lithium. Dinsmore Alter, the distinguished astronomer, foresees no problems in making electricity on the moon, using the sun's heat to boil water as primary source. But the capital requirement would weigh a lot."

Discussing the theoretical feasibility of earthly processes on the moon, with minor variations, Prof. Gaudin went on to say: "In the event we use precious water on the moon, we will want to recover it, entirely, if possible. Since water does not occur on the moon, nor oxygen, we either would have to make it from the rare hydrogen and oxides (or silicates), or import it from the earth. The label 'imported article' could certainly be attached to water on the moon, to assert its value! This is why recovery of water in a process using it would have to be complete. This not only means thickening followed by filtration but also thorough distillation and complete condensation of the vapor."

Urging that we, on earth, count our blessings, Prof. Gaudin said: "We are fortunate, indeed, to be living on a planet that has water and air, for without these fluids, problems, even in the inanimate world of metals, become enormously more difficult. The blessings of air and water, in the range of concentrations we know, have led to life, and that, in turn, has given us the fuels which we waste with such zest! Perhaps it is not too late to turn some of our efforts in the direction of husbanding the use of this capital for our great grandchildren, and to put the intervening time to good use in developing alternative ways of getting energy."

Luncheons and dinners

All-Institute functions got off to a warm and friendly start, with "just plain Joe" (Gillson)—as he characterized himself—presiding at the Welcoming Luncheon on Monday the 27th of February. He proceeded with the normal schedule of events by introducing the head table, although in a *sympatico* manner as "the ordinary guys at the head table" most of whom he had known for years by their first names.

W. H. Durrell, President of the Canadian Institute of Mining and Metallurgy, brought greetings from his Society and expressed his pride in AIME choosing a native-born Canadian as its 1961 President. In his turn, R. R. McNaughton declared himself to be looking forward to a very successful year.

The Annual Dinner of The Metallurgical Society, presided over by Carleton C. Long, featured the presentation of awards which were cited in the January issue of JOURNAL OF METALS. There were the *J. E. Johnson, Jr.* Award to Richard J. Wilson of Inland Steel Co.; and the *Champion H. Mathewson Gold Medal* to K. T. Aust and J. W. Rutter of the General Electric Research Laboratory. Y. Doi and K. Kasai of Sumitomo Metal Industries Ltd. in Japan, the recipients of the *Robert W. Hunt Award,* were unable to be present. But they sent word to the gathering expressing their thanks as follows:

"We feel honored to receive the glorious Robert W. Hunt Award of AIME for our trivial paper and would like to express our hearty gratitude.

"The progress of Japanese iron and steel making technique is chiefly due to your excellent results of researches and your friendly assistance in this field.

"We are very glad that our research contributed not only to the Japanese iron and steel industry but to the American.

"We are sorry we cannot attend this honorable prize-awarding ceremony and meet you personally.

"We hope American Institute of Mining, Metallurgical and Petroleum Engineers will make a further development and contribute to the welfare of mankind through ironmaking."

Presentation of the *Extractive Metallurgy Division Award* was made at that division's Annual Stag Luncheon and Business Meeting. Recipients were Professor Herbert H. Kellogg of the Henry Krumb School of Mines, Columbia University, and Sujit K. Basu, a graduate student at Purdue University.

The AIME Annual Banquet and Reception is always a gala, full-dress affair, featuring the presentation by the AIME of its highest awards.

The highest honor that AIME can confer is election to Honorary Membership in the Institute. In the 90 years of its existence, fewer than 100 have received this tribute. This year the AIME choose to elect three: Rene Victor Marie Perrin, Carl E. Reistle, Jr., and John Fairfield Thompson.

(Continued on page 438)

WELCOMING LUNCHEON

Thomas E. Millsop receives the Benjamin F. Fairless Award from President Gillson.

R. R. McNaughton of AIME and W. H. Durrell of CIM.

Frank H. Spedding receives the James Douglas Gold Medal from President Gillson.

Donald H. McLaughlin receives the Charles F. Rand Gold Medal from President Gillson.

AIME ANNUAL BANQUET

Honorary Members (l to r) John Fairfield Thompson, Rene Victor Marie Perrin, Carl E. Reistle, Jr.

Richard J. Wilson receives the J. E. Johnson, Jr., Award from John J. Golden.

John W. Rutter and Karl T. Aust receive the Mathewson Gold Medal from Thomas A. Read (right).

Herbert H. Kellogg receives the Extractive Metallurgy Division Award (on behalf of himself and Sujit Kumar Basu) from T. D. Jones (left).

The Citation embossed on the Certificate of Honorary Membership for Dr. Perrin reads, "For his outstanding application of science to metallurgy, particularly his conception and development of those revolutionary process for the manufacture of steel and ferro-alloys which achieve fast reaction rates by means of intimate mixing of liquid metals and slags."

The Citation embossed on the Certificate of Honorary Membership presented to Carl E. Reistle Jr., reads, "In recognition of his pioneering work in the application of engineering principles to the conservation of oil, of his inspirational leadership as an Engineer and an Executive, and of his great services to the Institute.

The Citation honoring Dr. Thompson reads, "A Metallurgist, scientist and administrator whose early appreciation of the unique qualities of nickel brought immense benefits to the world as well as outstanding success to the vast enterprise he has directed."

Presentation was made of the *Charles F. Rand Gold Medal* to Donald H. McLaughlin. Established in 1922, the medal has been awarded thirteen times since its inception. It is given for distinguished achievement in mining administration, the term *mining* being defined in its broad sense to include metallurgy and petroleum.

Donald H. McLaughlin received a B.S. from the University of California in 1914, followed by an M.A. and Ph.D. from Harvard. He has served as chief geologist for Cerro de Pasco Corp., and as consultant geologist for Homestake Mining and other companies. He was also chairman of the Div. of Geological Sciences at Harvard, and from 1941, he was successively Dean, College of Mining, Professor of Mining Engineering, and Dean, College of Engineering at the University of California.

A member of AIME since 1916, Dr. McLaughlin was President of the Institute in 1950. He holds directorships in many companies and was president of Homestake Mining for several years. He is now chief executive officer and chairman of the board. During its first five years, he was Chairman of the Advisory Committee on Raw Materials of the Atomic Energy Commission.

The citation accompanying the *Rand Gold Medal Award* to Dr. McLaughlin reads: "In recognition of his distinguished career as an administrator in mining and scientific education; as an outstanding executive in many segments of the mining industry, and as an advisor to Government."

Other awards made at the Annual Banquet—cited in the January issue of Journal of Metals—were the *James Douglas Gold Medal* to Frank H. Spedding, *the William Lawrence Saunders Gold Medal* to Marcus D. Banghart, the *Anthony F. Lucas Gold Medal* to Edwin O. Bennett, the *Erskine Ramsay Gold Medal* to Donald Markle, and the *Benjamin F. Fairless Award* to Thomas E. Millsop.

A highlight of the Annual Banquet was the traditional introduction to the incoming president of the Institute—Ronald R. McNaughton.

Addressing banquet guests, he sounded what might be the keynote not only for 1961 but for the entire decade of sixties: "As engineers and scientists, AIME members should accept challenge as a way of life and look forward eagerly and with confidence to improving the living standard, not only of our own people but also of those in other, less fortunate countries, through continued scientific and engineering progress."

—FWS

THE PRESIDENTIAL ADDRESS,

STATE OF THE INSTITUTE

(A Summary)

by JOSEPH L. GILLSON
President of AIME, 1960

In this past year of our Institute's life, February 1960 to February 1961, we had some major problems to face, as did our members, since businesses in which they were engaged were feeling the recession.

The major problems confronting us during this past year were:

1) Financing the new Engineering Center.

2) Keeping our three almost autonomous societies working together and toward a stronger AIME.

3) Cooperation with other engineering societies—the Functional Plan.

4) Licensing and registration, and the Model Law.

5) The reorganization of the Council of Section Delegates.

6) Combatting the slump in the appeal of engineering to the young students.

The New Engineering Center

That we needed a new building to house the staffs of the many engineering societies had been obvious for many years. The present building was built in 1906 when the combined membership of the so-called *Founder Societies* was only 16,000. Our own membership alone is now 35,000, and the membership of the societies with offices in the building is over 200,000. Naturally the number of staff members has had to grow.

Although it was suggested that AIME move to Pittsburgh, the decision to stay in New York and to build a fine building on a prestige location opposite the United Nations Plaza was made by a competent committee. Our representatives were H. DeWitt Smith, Harold Decker, and Clyde Williams.

I was put in charge of fund raising from our members by then President Kinzel. I was not responsible for the total amount assigned to us; but nearly every other decision taken was mine.

It was decided to give each section a quota or goal, and many of the sections went to work diligently. The support of their Institute by members in such widely scattered sections as Utah, Philadelphia, Oregon, Gulf Coast, Pennsylvania Anthracite, Hugoton, Lehigh Valley, St. Louis, Panhandle, Ohio Valley, Arizona, Hudson-Mohawk, Carlsbad, Florida, New York Petroleum, Uranium, Tri State, Montana, Fort Worth, Minnesota, Pittsburgh, San Francisco, and East Texas as of December 30, 1960 was most gratifying. The New York area, assigned a very high goal of $150,000, came through wonderfully. To date, the New York Mining and Metallurgical Section has contributed more than $140,000; the New York Petroleum Section has given over $13,000—a grand total exceeding $153,000. Firms in the greater New York area have contributed $2,829,000 of the $4,959,000 received from all industrial organizations.

After I became president I turned the chairmanship of the fund raising committee over to Lloyd Elkins, and he has beaten the drums loudly throughout the year. At the end of 1960 we called the campaign by sections, over. We decided to make one more appeal, a personal solicitation by mail to every member with a letter signed by the president. This went out at the end of January.

As of February 28th (and I am sure that we have not received all of the replies from this direct appeal to all members) we had collected

From members in Mining and Metallurgical Sections	$307,911
From members in Petroleum Sections	110,343
From Foreign members, and from various committees and Sections, including the Woman's Auxiliary	67,456
Total (unadjusted)	$485,710

This left us still short of our quota of $500,000, but through the response to the President's appeal, this has been further reduced.

Editor's Note: Adjustments for cancellations, etc., totalling $6,810 must be deducted from the above amount, reducing the Grand Total (as of February 28) to $478,900. However, as of April 7, this adjusted total has increased to $483,214.

We have arranged to borrow the difference from the Jackling Fund, which was given by Mr. Jackling for the use of the building. We have drawn on it for office expense in connection with the accounting of the gifts from members; and we expect to draw heavily on it for new furniture and fixtures and for moving into the new building. We had hoped to keep the balance invested and use the interest to reduce our rent in the new building, which will be higher than the rent we have paid in the old building. Whether next year's Board will approve plans to refund this money borrowed to meet our current obligation has not yet been decided.

I want to take this opportunity to thank every member who has contributed toward this fund, and to the men in each Section who have worked so hard to raise the money. I want particularly to thank the ladies of the Woman's Auxiliary who contributed $16,236 without even being asked to make any contribution at all.

Cooperation among AIME's constituent societies

We have divided the Institute into three Societies, and this arrangement has been functioning well long enough for us to realize that it was a most wise move. We have learned from experience that although

people are gregarious and like to flock together, there must be a considerable attraction of common interest to hold them together. In our Institute we have a wide spectrum of interests with the only common bond being that all have something to do with metals, minerals, and fuels that come out of the ground.

With all of this divergence of interest, it is important to ask what keeps us together; should we stay together; and how best can we promote better common associations? I think that there is no question about these points. We must stay together.

AIME has inherited prestige like that enjoyed by the American Institute of Electrical Engineers, the American Society of Mechanical Engineers, the American Society of Civil Engineers, and the American Institute of Chemical Engineers. Although many in each society are loyal only to the Society, nevertheless the majority of members consider that they belong to AIME and are proud of it. Our common interest in the Engineering Building, our membership in the Engineers Joint Council and in the Engineering Manpower Commission, the Engineering Foundation, and the Engineers' Council for Professional Development—are all unifying factors.

Inflation unites us. We can no longer afford a multiplicity of staffs, offices, meeting places, and publications. We must necessarily unite as much as possible. Repetition and multiplication of meetings, both technical and organizational, force too much of a burden on our time and our expense accounts.

We need a unifying central organization composed of the Board and officers of the Institute, the Secretaries, and the staffs, to hold our three societies together. During the year we settled a very important point, namely, that the Institute Secretary and his office would be paid uniformly by all members.

The Institute President is a unifying influence. This year I went to nearly every section or meeting to which I was invited, and spoke briefly. I was there to prove the connection between that local meeting and the top Institute organization. The president, however, cannot do it all. Each officer of the Board of the Institute and of each society as well as each member must say to himself, "I am a member of AIME."

Inter-Engineering society relations

There is no doubt that the Engineers Joint Council has increased its prestige, particularly under Dr. Kinzel's leadership. This will increase this year with Mr. Landis as president and Dr. Holbrook re-elected as vice-president. The prestige of ECPD is established and is continuing. We can be proud to be represented on its board.

EJC has set up a new committee to coordinate technical programs and meetings to avoid geographical overlapping, as well as technical overlapping. It will take some time for this committee to be effective, but it should have a strong unifying influence eventually.

EJC has applied to the Department of Internal Revenue to be classified as 501 C-3. If it is given that status, then EJC cannot engage in various types of activities that are generally classed as *lobbying*, or those that benefit individuals rather than the public.

It has been proposed by the Electrical Engineers, (and in that recommendation they have been joined by the Mechanical Engineers) that the National Society of Professional Engineers be set up in its relation to the other societies as EJC is for technical matters, and as ECPD is for educational matters,—i.e., to be the *political arm* of the engineering societies. This scheme is called the *Functional Plan*; and the Electricals, Mechanicals and, of course, NSPE have been putting pressure on us to support it.

However, NSPE is a society of individual members and cannot accept society memberships as do EJC and ECPD. The latter two are run by a Board on which each member society has representatives. NSPE is run only by and for its own members. To be a member of NSPE one must be a licensed and registered engineer. No member of AIME can join NSPE unless he is registered, and only a very small number of our members are. Hence we cannot support the Functional Plan to direct NSPE to look out for the political life of our members, since we have no way of telling the Board of NSPE what we want done, and no influence to get them to do anything for us.

We have studied NSPE and have had observers at recent meetings. We believe that the officers and directors are sincere and intelligent men, devoted to the benefit of the engineering profession. If they will open their membership to members of AIME, it is my opinion that we should urge our members to join in sufficient numbers to influence the councils of the State Societies and the national organization.

We have examined the registration laws in all of the states and have learned that our members can get registered in many states. It is my opinion that we should urge all of those who can register to do so; and once registered, they can join NSPE.

Licensing and registration

We have studied the licensing and registration laws in each state. Although drawn especially for civil, mechanical, and electrical engineers, nevertheless, geological engineers can be registered by taking an examination in their field of competence in 15 states; mining engineers in 27 states; metallurgical engineers in 28 states; and petroleum engineers in 19 states. Older men with a number of years of practice in positions of responsibility can be registered under what is called the *eminence clause*.

Many people believe that requirements for registration and licensing of engineers will become almost universal in 15 years. The fact that a very large number of companies, both large and small, are obtaining contracts with the Government for some phase of our National Defense program causes a substantial number of engineers to become involved in what is called the *public health and welfare*. Most of our engineers employed in industry have seen no reason for registration, and in most states they do not have to be registered. However, lots of things can and do happen. A company might dump chemical or radioactive wastes into streams or into the ground and be sued in court for damages. One of the first questions asked of the expert for the company could be, "Are you a registered engineer?" If the answer be "No," the expert is likely to be excused and not permitted to testify further.

As persons advance in companies to positions of responsibility, there will be more and more demands that those senior persons be registered. If they have neglected to take the basic examination in fundamentals upon graduation from engineering school, they are going to find it increasingly difficult to pass

examinations in the fundamentals of mathematics, physics, and strength of materials.

This is why we urge our student members to take the basic examination in fundamentals (the so-called *Engineer-in-Training* examination) just as they graduate when all of that technical material and mathematics is fresh in their minds. Senior engineers who can become registered in many states under the eminence clause should do so as soon as possible.

The National Council of State Boards of Engineering Examiners (NCSBEE) has been working on a *Model Law*, and had hearings in New York and Portland last year. We had observers at each of those meetings. We could subscribe to nearly every section of the proposed Model Law except that we felt that it should specify that a man be examined in his field of competence, not just in *engineering*. We have accepted the Model Law on condition that our *competence clause* be included in it. We learned that to be admitted to the discussions at the NCSBEE, we should be a sustaining member of that organization. We have voted to pay the annual fee of $500 to permit AIME to be a sustaining member.

Naturally, this Model Law is not going to be accepted without amendment by the legislatures of fifty states; but at least it is a guide for each to follow. We hope and believe that by working with the State Boards and the NCSBEE we can further their recognition of our fields of engineering.

Our conclusion is that, like it or not, universal registration of engineers, both in industry and in private practice, is inevitable; and when something is inevitable, you had better adapt yourself to it. If it involves passing examinations which are simple for our college graduates, let them take such examinations. Our problem is to get the state boards to recognize that the technology of this rocket age is exploding, and the definition of an engineer made in the 1920's or 1930's is out-of-date. There are geological, mining, metallurgical, and petroleum engineers, as well as civil, electrical, and mechanical.

Increasing the appeal of engineering to students

Registration of new students in the freshman and sophomore classes of most of the engineering schools is below a year ago; and in some of the disciplines in our fields of interest, the drop is very serious indeed. At the Massachusetts Institute of Technology, students enrolled in science exceed in number, for the first time, those enrolled in engineering. Many feel that the swing is cyclic and that the number of students enrolling in the engineering courses will be back to normal within a year or two. Right now we are in the glamor of the rocket age. Scientists designed the rocket. If it failed to go into orbit, the fault was the engineer in the dirty overalls who did not build it correctly.

All of these students cannot make a career in pure physics and mathematics since there cannot be enough jobs for them. They must combine their physics and mathematics with engineering since that is where there will be an adequate number of jobs.

We in the Engineering Societies, however, cannot just sit idly by, wringing our hands and hoping for the best. What can we do that will be effective? Reaching 250,000 boys in 25,000 high schools is a frustrating problem. We have alerted our sections and of course most of them were aware of the situation before. Visits to the high schools by well-chosen engineers and talks about the opportunities in engineering may help.

We are studying how to assist two or more organizations which are now in existence trying to help the high schools arouse an interest in science and engineering in their students. The one that appeals to us most is called JETS (Junior Engineering Technical Society, Inc.). This organization was founded by the Dean of Engineering at Michigan State University in Lansing. Two of our prominent members, J. C. Calhoun, Vice-Chancellor of Texas A. & M., and Julian Feiss of Kennecott Copper Corp., have been serving on the Board of Directors of JETS. The student groups in the high schools are called chapters, and the number of these is growing very rapidly. From a start in 1950, there were 200 in June 1957, 500 in June 1959, and 650 in June last year.

We have not yet been asked for money to support the program, but rather for help in preparation of material which the national office in Lansing sends out to all of its chapters. For instance, on April 12, 1961, they mailed out a packet on Geology and Mineralogy; and in May, at their National Engineering Project Exposition, there is a section on Petroleum Engineering. Projects are theses, models, etc. which students prepare for awards.

Other organizations actively working in the high schools are JESSI (Junior Engineers Scientists Summer Institutes) and FSA (Future Scientists of America). The former puts on summer school programs for high school students, the second promotes prize paper contests.

Membership

In a recession year, applications for new memberships are at a record high, but losses are also up. As a matter of fact, however, our gross gain was greater than in any previous year, as follows:

Mining	1455 members	34.25 pct
Metals	1016 members	23.92 pct
Petroleum	1777 members	41.83 pct
	4248 members	100.00 pct

Our losses were higher than previously, but percentage-wise were about the same as in the last two years. Percentage loss of membership at the end of 1958 was 7.22 pct; of 1959—7.92 pct; of 1960—7.95 pct.

We cannot do anything about losses from death, and as the Institute grows, this number must increase numerically. Remember that we have increased our membership from 14,922 in 1940, to 21,616 in 1950, to 36,745 in 1960. The increase in membership between 1940 and 1960 is 1½ times the membership in 1940; and the increase in membership in the ten years 1950 to 1960 is a number greater than the total membership in 1940 and is 75 pct of the membership in 1950. Since the 75 pct increase over 1950 is a net increase, considerably over 50 pct of the current members have been members less than 10 years.

Nevertheless, losses are a major problem. With a rapidly growing organization, a large number of members have been in such a short time that they have developed little of the loyalty that comes from long association.

Conclusions

The Institute has had a successful year, particularly in accomplishing its main purpose of bringing meetings within the geographical and financial range of more of our members, and of publishing a large number of excellent papers in our journals, transactions, and other books.

Phases and Processes

HIGHLIGHTING CURRENT DEVELOPMENTS IN METALS

Blast Furnace Technology

by R. L. Stephenson, U.S. Steel Applied Research Laboratory

(A review of papers presented at the Iron & Steel Division's sessions on Blast Furnace Technology during the 1961 AIME Annual Meeting in St. Louis, Mo.)

Thermal Balance For a Ferromanganese Blast Furnace by W. H. Burr and J. H. Bergmark, Duquesne Works, U. S. Steel Corp.

This paper presented by W. H. Burr compares heat balances for the production of basic pig iron by the conventional blast-furnace process with those for the production of ferromanganese both with a conventional air blast and with a blast enriched to 28.8 pct O_2. This comparison shows that the heat requirement for the ferromanganese blast furnace is much greater than that for a basic iron furnace and also that a greater portion of the total heat required must be in the high-temperature range above 2500°F. By enriching the blast with oxygen a larger percentage of the total heat can be produced in this range. The use of a blast containing 28.8 pct O_2 increased the production rate of the ferromanganese furnace 54 pct and decreased the coke requirement 13 pct.

The use of blast-moisture additions which promote indirect reduction is beneficial for a basic iron furnace when high hot-blast temperatures are used; however, moisture has only an undesirable effect on the ferromanganese blast furnace where almost all of the reduction of MnO must be done as direct reduction at very high temperatures. Sintering the ores prior to charging has shown practically no benefit in the ferromanganese blast furnace although a sinter burden promotes indirect reduction and lowers the coke rate in a basic iron furnace.

In the ferromanganese blast furnace, the production rate is limited only by the rate at which high-temperature heat can be supplied to the hearth; consequently, this process is greatly accelerated by the use of oxygen enrichment and high hot-blast temperature.

Kinetics of Reduction of FeO and MnO From Silicate and Aluminate Slags by S. K. Tarby, Lehigh University and W. O. Philbrook, Carnegie Institute of Technology. The following summary was prepared by W. O. Philbrook:

The reduction of MnO and FeO from CaO-Al_2O_3 and CaO-SiO_2-Al_2O_3 slags to carbon saturated iron in stationary graphite crucibles was found to proceed in two stages. It is proposed that this process is controlled by the rate of transport of Mn^{2+} or Fe^{2+} ions to the slag-metal interface in both stages. In the first part of the process, the stirring caused by carbon monoxide evolution results in turbulent flow in the slag, with the result that the mass transfer coefficient is a function of the reaction rate. As the boil subsides, the slag reverts to streamline flow conditions where the boundary layer becomes independent of further changes in reaction rate, and the process behaves as one with simple diffusion control. This change occurs well before the reduction rate becomes limited by simultaneous slow reduction of SiO_2. The latter limitation has prevented attainment of the true equilibrium distribution ratio for manganese in previously published studies.

Reduction Kinetics of Hematite in Hydrogen-Water Vapor-Nitrogen Mixtures by W. M. McKewan, Fundamental Research Laboratory, U.S. Steel Corp.

Dense hematite pellets were reduced in hydrogen-water vapor-nitrogen mixtures in the temperature range of 700° to 1000°C and at a total pressure of 0.97 atm. The rate of reduction per unit area was directly proportional to the partial pressure of hydrogen when the ratio of hydrogen to water vapor was constant. As the ratio of hydrogen to water vapor decreased, the reduction rate decreased and approached zero at the wüstite-iron equilibrium point. The enthalpy of activation for this reaction was shown to be 15,400 cal per mole.

In addition, an equation was derived from entirely theoretical considerations that was shown to fit the experimental data.

W. E. Marshall of Armco Steel Corp., presented a paper on **Taconite Pellets in the Blast Furnace,** which was published in the April issue of JOURNAL OF METALS.

Fuel-Oil Injection Tests in a Blast Furnace at the Cockerill-Ougree Works in Liege, Belgium by E. Noel, Ougree Works; J. Molderez, Seraing Works; and A. Poos, Centre National de Recherches Metallurgiques, Belgium.

This paper, presented by Mr. Poos, describes tests in which fuel oil was injected through the tuyeres of a 12.5 ft hearth-diameter furnace. While fuel oil was injected, the operation of the furnace became smoother and the sulfur content of the metal was controlled more easily. Indirect reduction increased and the coke rate decreased. Every lb of fuel oil replaced about 1.8 lb of coke when a 40 pct sinter burden was used and 1.6 lb of coke when a 90 pct sinter burden was used. For a constant driving rate (that is, for the same quantity of bosh gas per hr), the injection of 120 lb of fuel oil per net ton of hot metal gave an increase in production of about 3 pct.

During the tests, temperature and chemical composition of the furnace gas were determined by the means of vertical and horizontal probes; however, additional data will be necessary before the full meaning of these results can be calculated.

CIM's Annual Meeting

by Edward Robie, Secretary Emeritus, AIME

Canadian Institute of Mining and Metallurgy's Annual Meeting, held in Quebec City March 20-22, proved one of the high spots in the long series of successful meetings of the CIM. The technical program, the social events, the attendance, the meeting place, and the weather combined to make it a most rewarding affair.

A total of 24 technical sessions were arranged for the three-day meeting, with 96 papers on the program. Metallurgy, including extractive metallurgy and mineral dressing with five sessions, physical metallurgy with two, and iron and steel production with two, dominated the meeting. Geology and geophysics had five sessions of five papers each, metal mining three sessions, industrial minerals three, coal one, petroleum and natural gas one, and two sessions were devoted to general subjects and joint sessions. The attendance taxed the capacity of some of the small meeting rooms. Discussion often had to be postponed or eliminated to give time for a more complete presentation of the papers.

SOCIAL ACTIVITIES

Attendance totaled approximately 1600, including close to 500 ladies, attracted no doubt by the charming atmosphere of the Chateau Frontenac, the excellent neighboring restaurants, of which the Kerhulu and Vendome were outstanding, and the many interesting spots in the historic city. Industrial companies in the mining and metallurgical field outdid themselves in providing refreshment, not only in individual rooms, but in daily public receptions before each luncheon and before the annual dinners on Tuesday night and the annual ball on Wednesday. The dinner on Tuesday night featured the presentation of major Institute honors, including the awarding of the Selwyn G. Blaylock Medal to AIME President R. R. McNaughton. The Medal is awarded to a member of the Canadian Institute for distinguished service to Canada through exceptional achievement in the field of mining, metallurgy, or geology.

Mr. McNaughton is manager of the metallurgical div. of Consolidated Mining and Smelting Co., of Canada, Ltd. The citation accompanying the award reads, "In recognition of his numerous contributions to the smelting and refining of lead and zinc in particular, and to the production of many of the metals occurring in the Sullivan ore bodies and including his latest contribution in the production of iron in commercial quantities from Sullivan mine tailings."

Before the ball, the Gardner-Denver Co. invited what must have been a majority of registrants to a buffet supper that was the most outstanding affair of its kind that we have ever attended.

The variety show on Monday night for gentlemen and ladies presented four acts that were among the best that we have ever seen at a CIM or AIME meeting. Following former practice, the ladies and gentlemen had separate annual dinners, a practice which lends itself better to the limited capacity of most hotel ballrooms, and permits more interesting programming for each group. Several pre-session movies of general interest were the prizes for early attendance.

Some had hesitated to drive their own cars to the meeting, fearing stormy weather at that time of the year in the North, but each day was sunny, and all Quebec and Ontario main roads were free of snow and ice. Next year's annual CIM meeting will be held in Ottawa, presumably at the usual time, in April, which was not possible this year. CIM's affairs for the year will be in the capable hands of the new president, J. B. (Jim) Mawdsley, head of the Dept. of Geological Engineering at the University of Saskatchewan, and C. (Jerry) Gerow, the secretary, of Montreal, and his assistant, E. G. Tapp.

Of general interest was a most informative talk by Prof. Rice of Toronto, on what is going on in Soviet Russia that mining engineers should ponder over. Large expenditures are made for research in various mining fields which were detailed by the speaker. He was impressed by the tremendous significance attached to the mineral industries in terms of prestige accorded to workers in the field, and the rate of investment in capital works. There are 40,000 geologists, of Bachelor level or higher, engaged in mineral exploration.

TECHNICAL SESSIONS

A panel discussion on *What's New in Materials Handling* was featured at the Industrial Minerals sessions. This group is to be distinguished from the common herd at CIM meetings: its members have a small red label pasted over their registration badges and it was the only division that held a separate luncheon on Tuesday!

Mineral dressing had somewhat less attention than at some previous meetings, but there were papers describing the Levack mill and sand plant, the Quebec Government pilot plant, copper activation of pyrite, and the use of sulfur dioxide in flotation.

In the field of metallurgy, most attention was given to the subject of extractive metallurgy, with a special forum on roasting. Papers on zinc roasting practice at Flin Flon, suspension roasting at Trail, fluid bed practice at Red Lake, practices at Copper Cliff, magnetic roasting and two papers on roasting in the iron and steel industry were presented. Presumably all of them will be published in the CIM Bulletin. One paper reviewed the practice on aluminum smelting; another described the leach-precipitation-flotation practice at the Rosita mine in Nicaragua, and the Keyes autoxidation plant used to produce acid for the leach. The research work being done on improving the quality of the iron ore shipped from the Labrador-New Quebec area proved an interesting subject for a paper. Another discussed the development in Canada of structural steels of higher strength and improved resistance to brittle fracture.

Four papers were presented at the physical metallurgy session: *An Investigation of Spalling and Crater Formation by Hyper-Velocity Projectiles; Studies of the Low Temperature Tensile Properties of Some Transition Metals and Alloys; Properties of Cast Steel Produced from Direct Iron;* and *Production of High Purity Iron by the Floating Zone Method.*

RESULTS OF 1960 QUESTIONNAIRE

ON ADMINISTRATION OF STATE ENGINEERING REGISTRATION LAWS

The following is a summary of the answers received to six questions that were sent to each state. To date, Indiana, and Iowa have not responded to the questionnaire.

1. Do you register all engineers in one category of Professional Engineer?

YES: Ala., Ark., Colo., Conn., Del., Ga., Idaho, (with qualifications) Ill., Kan., (with notation of specialization) Me., Md., Miss., Mont., Neb., (with qualifications) N. H., N. J., N. M., N. Y., N. D., Ohio, Okla., S.C., S.D., (with qualifications) Tenn., Texas (but 4 categories), Va., Fla.; Missouri replied no answer could be given.

NO: (Would qualify geologists): Minn., Nev., and S.D. (Would qualify metallurgists): Ariz., Ky., La., Mass., Mich., Ore., S. D., Wash., W. Va., District of Columbia. (Would qualify mining engineers): Alaska, Ariz., Ky., Mass., Minn., Nev., Ore., Pa., Utah, S. D., Wash., W. Va., District of Columbia. (Would qualify petroleum engineers): Ariz., Calif., Ky., La., S. D., W. Va. Oregon allows the field of proficiency to be added in parenthesis.

2. On the examination in the fundamentals of engineering (some States called it "Engineer in Training Examination") are there questions in various fields of engineering and, if so, is there a voluntary selection of alternative questions permitted?

NO: (Not any voluntary selection): Ala., Alaska, Ariz., Conn., Del., Fla., Ga. (But some optional questions), Mass., Mich., Miss., Mont., Neb., Nev., N. M., N. Y., N. C., Ohio, Ore., Pa., S. C., Tenn., Texas, Va., W. Va.

YES, but only in Civil, Electrical, and Mechanical Engineering fields: Ark., Calif., La., Me., N. J., Wash.

Those which permitted voluntary selection including our fields of interest: Calif., (petroleum only), Colo., Idaho (mining only), Ill. (all but geology), Kan., Minn. (all but petroleum), N. D. (mining and petroleum only), Okla., S. D., Utah, Wis., Wyo. (mining and petroleum only), District of Columbia.

3. Does the subsequent examination (in many cases given four years after the basic examination, if that is taken upon graduation) permit the candidate to select questions in his field of competence?

States permitting selection in geology: Ark. (has had no applicants), Colo., Del., Kan., Minn., Mo., Mont., Nev., N.M., N.D., N.C., Ore., S.D., Texas, Utah, District of Columbia.

States permitting selection in metallurgy: Ala., Ariz., Ark., Colo., Conn., Del., Fla., Kan., Ky., La., Mich., Minn., Miss., Mo., Mont., Nev., N. H., N. M., N. C., Ohio, Ore., Pa., S. C., S. D., Texas, Va., Wash., W. Va., Wis., District of Columbia.

States permitting selection in mining engineering: Alaska, Ariz., Ark., Colo., Del., Fla., Idaho, Kan., Ky., La., Minn., Miss., Mo., Mont., Nev., N. M., N. C., Ohio, Okla., Ore., Pa., S. C., S. D., Texas, Utah, Va., W. Va., Wis., Wyo., District of Columbia.

States permitting selection in petroleum engineering: Alaska, Ark., Calif., Colo., Kan., Ky., La., Md., Miss., Mont., N. M., N. C., Ohio, Okla., Ore., S. D., Texas, Utah, W. Va., District of Columbia.

4. Does the State register engineers on the basis of a degree from an accredited engineering school and after some years of engineering practice, without taking an examination in the fundamentals of engineering?

YES: Ala. (4 years), Calif. (eminence clause), Colo. (after 15 years), Conn. (15 years), Del. (4 years), Fla. (very rare), Idaho (after 4 years), Kan. (after 4 years), Ky. (after 4 years of acceptable practice), La. (after 5 years), Me. (after 4 years with interview), Mass. (after 4 years), Miss. (after 4 years), Mont. (after 12 years), Neb. (in special cases), Nev. (after 20 years), N. H. (12 years), N. C. (after 8 years), Okla. (3 years), Pa., (4 years), S. C. (after experience acceptable to Board), Tenn. (after oral examination), Texas (8 years), Utah (12 years), Virginia (at age 40 and after 4 years of practice), Wis. (after 12 years), Wyo. (25 years), District of Columbia (after 12 years, applicant must appear for interview).

5. If the State does not require an examination in the fundamentals for engineers with experience (i.e., those which replied "YES" to Question 4) does it require a written or oral examination in the engineer's field of experience?

YES: Colo., Fla., Ga., Idaho, Ky., La. (if not from accredited college), Me. (rarely), Mich. (had replied NO to Question 4), Mont., Neb., Nev. (usually), N. H. (at Board's option), N. J. (oral), N. M. (written), N. C., Okla. (after 20 years), Ore., Pa., S. C., S. D., Tenn., Utah (after consideration by Board), Va. (oral), V. Wa., District of Columbia (oral).

6. Can an engineer licensed and registered in any one of the other States, and as a result of examinations in those States, be licensed in this State without taking an examination in fundamentals or in the field of specialization?

YES: (if the examination in the other States was equivalent to theirs): Ala., Alaska, Ariz., Ark., Calif., Colo., Conn., Del., Fla., Ga., Idaho, Ill. (with qualifications), Kan. (probably after interview), Ky., La., Me., Md., Mass., Mich., Minn., Miss., Mo., Mont., Neb. (if registered in other States before Dec. 28, 1959), Nev., (must appear for interview), N. H., N. M., N. Y., N. C., N. D., Ohio, Okla., Ore., Pa., S.C., S. D., Tenn., Texas, Utah, Wash., W. Va., Wis., Wyo., District of Columbia.

AIME STAFF:

SECRETARY—ERNEST KIRKENDALL

ASST. SECRETARIES—J. B. ALFORD, H. N. APPLETON, J. C. FOX, R. W. SHEARMAN, C. J. HICKS

ASST. TREASURER—JOHN LYNCH

METALLURGICAL SOCIETY STAFF:

SECRETARY—R. W. SHEARMAN

ASST. SECRETARY—D. C. JOHNSTON

NEWS OF YOUR PROFESSION

O. G. Lellep Receives Lueg Gold Medal From German Metals Group

O. G. Lellep was awarded the Carl Lueg Gold Medal by the German Verein Deutscher Eisenhuettenleute during its centennial celebration in Dusseldorf in November. The medal was presented to Dr. Lellep for his pioneer work in the application of oxygen in steelmaking. He experimented as a free lance inventor at the Gutehoffnungshuette in Germany without pay from 1936 to 1940 and discovered new ways of melting steel in a simple, compact open-hearth furnace without regenerators.

In 1939 Dr. Lellep was the first to demonstrate how a phosphorus containing molten iron could be converted into good steel in a 1-ton capacity converter by blowing with pure oxygen through a water-cooled bottom. Dr. Lellep's co-workers, Drs. Trenkler and Schwarz, improved the method and later developed the so-called LD process.

Kellogg Fellowship In Extractive Metallurgy Goes To Richard Lloyd

The Herbert H. Kellogg Fellowship in Nonferrous Extractive Metallurgy for 1961-62 at the Henry Krumb School of Mines, Columbia University, has been awarded to Richard Lloyd.

It is one of three graduate fellowships in nonferrous extractive metallurgy honoring past chairmen of EMD. Established by American Metal Climax Foundation, Inc., of New York, each grant totals about $4000 per year (JOURNAL OF METALS, March 1961, p. 227). Besides Mr. Kellogg, the scholarships are in honor of A. W. Schlechten of the Missouri School of Mines and Metallurgy, and Reinhardt Schuhmann, Jr. of Purdue University.

Mr. Lloyd, the recipient of the Kellogg Fellowship, received a B.S. degree in chemical engineering from Tufts College in 1949. From 1949-1956 he was employed as assistant superintendent at the Tacoma Smelter of American Smelting and Refining Co. He also served two years with the US Army during this period.

In 1956, Lloyd was admitted as a graduate student to the University of Washington where he earned a M.S. degree in extractive metallurgy in 1958. On graduation he was appointed assistant professor of extractive metallurgy, a position which he held until September 1959 when he went to Columbia.

Lloyd, who is a member of AIME, has finished most of his course work for the Ph.D., and expects to spend full time on research in 1961-62. His thesis topic is *An Investigation of the System Pb-S-O at High Temperature.*

Fall Meeting Abstracts

June 28 is the deadline for receipt of abstracts to be considered for presentation at IMD-sponsored sessions during the 1961 Fall Meeting of The Metallurgical Society, which will be held from October 23-26 in Detroit.

In order to be considered for inclusion in the program, each submission should consist of the following:

1) Three copies of a 200-300 word abstract, typed double-space on one side only. (No photographs, figures, tables, or diagrams, please; however, brief acknowledgments of research sponsorship may be included if applicable.)
2) One copy of an information sheet containing complete mailing address of each author together with title of paper being submitted.

Submissions should be forwarded to:

D. C. Johnston, Secretary, IMD
The Metallurgical Society of AIME
29 West 39th Street
New York 18, New York

ASM Publishes Eighth Edition of Metals Handbook

The eighth edition of the *Metals Handbook* has been issued by the American Society for Metals. The volume, *Properties and Selection of Metals*, contains 1300 pages and sells for $30.00. Devoted exclusively to the selection and properties of metals, the new book is the first of a projected series of volumes which will cover all branches of metals engineering and metalworking. The book emphasizes the factors of economy and fabrication in metals selection. More than 1300 metals specialists contributed to the volume.

An enlarged section on carbon and low-alloy steels consists of 26 major articles: 12 on steel products and 14 on selection for specific engineering properties, economy, and special processing considerations. The section carries articles covering all commercial steel product forms, and articles dealing specifically with selection for maximum yield strength at minimum cost, hardenability, fatigue resistance, notch toughness, wear resistance, and resistance to corrosion.

Major processing factors are covered in articles on selection for economy in machining, selection of low-carbon steel sheet formability, deep-drawing, and porcelain enameling.

There is a section on stainless steels which covers all stainless steels (cast and wrought), including recently-developed precipitation-hardening alloys. Aluminum, copper, and the other major nonferrous metals are covered. Other sections are devoted to iron-base superstrength alloys, nickel-base and cobalt-base alloys, and titanium and titanium alloys.

A glossary of about 2800 definitions appears at the front of the book which also has 6700 illustrations, 1841 tables, more than 1500 examples, and data compilations on 456 alloys.

News of The Extractive Metallurgy Division

Long-Range Planning Committee Report Is Adopted

Long-range plans have been adopted by the Extractive Metallurgy Division to provide for coordinated programming and publications. The study committee was under the chairmanship of Richard C. Cole.

Of special interest is a series of Symposiums. In 1962 at the New York Annual Meeting an International *Symposium on the Extractive Metallurgy of Aluminum* will be held. R. A. Lewis of Kaiser Aluminum Co. is Conference Chairman. This *commodity* topic will alternate with a *functional* topic in 1963 in Dallas, Texas, when the symposium will be *Unit Processes in Hydrometallurgy*. M. E. Wadsworth of the University of Utah will serve as Conference Chairman.

For 1964 in New York, the symposium topic will be Extractive Metallurgy of High Temperature Metals. In 1965 for the Chicago Annual Meeting, Unit Processes in Pyrometallurgy is planned.

The ad hoc Long-Range Planning Committee also recommended that the Extractive Metallurgy Division should consider active participation in Regional Meetings. The possibility of an up-to-date text on extractive metallurgy for use at senior and graduate levels is under consideration. A permanent Long-Range Planning Committee has been established.

Fall Meeting Plans For 1961

At the 1961 Fall Meeting of The Metallurgical Society to be held at the Pick-Fort Shelby Hotel in Detroit, October 23-26, the Extractive Metallurgy Division will sponsor two symposiums of two sessions each on *Vacuum Metallurgy* and on *Nuclear Fuel Reprocessing*. The program committee is headed by W. R. Opie.

Phillips Selected As 1962 EMD Lecturer

Dr. Albert J. Phillips, vice president and director of research, American Smelting and Refining Co., has been selected to present the fourth Extractive Metallurgy Division Lecture. This will be given during the 1962 AIME Annual Meeting in New York.

Bylaw Changes Announced

Under the able leadership of J. D. Sullivan, bylaw revisions have been recommended to keep abreast of changes in Division procedures.

Annual Lecture Committee Established

Under Article IX, Section 1 ("There shall be the following standing committees . . .") add *Lecture Committee*.
Under Article IX, add new Section 7:

Section 7—Lecture Committee. The Lecture Committee shall consist of four members of the Division, one appointed each year for a term of four years by the Chairman of the EMD, subject to the approval of the Executive Committee. The member in his second year of service shall be Chairman of the Lecture Committee.

a. It shall be the responsibility of the Lecture Committee to select an outstanding scientific leader to present a lecture on a technical subject of particular interest to the Division at a meeting approximately two years following the time of his selection. The selection is subject to the approval of the Executive Committee, and the Division Secretary shall promptly thereafter report the action to the Papers and Programs Committee. The lecturer-nominee shall be notified by written invitation prepared by the Division Secretary and signed by the President of The Metallurgical Society at least eighteen months prior to the date of the lecture.

b. The Lecture Committee shall be responsible for the arrangements of the lecture presented during its year of office. It also shall be responsible for the itinerary of the lecturer. Financial arrangements shall be subject to the approval of the Executive Committee. An appropriate citation shall be prepared by the Committee for presentation to the lecturer. The lecture shall be known as the EMD Lecture and the lecturer shall be known as the EMD Lecturer for that year.

Objective of the Division Redefined

Article II, Section i, revised to read:

The object of the Division shall be to promote the advancement of metallurgical knowledge and to promote high medium for communication and cooperation between those interested in all phases of extractive metallurgy with emphasis on the extractive metallurgy of the nonferrous metals; to represent The Metallurgical Society, insofar as extractive metallurgy is concerned, within the rights given in The Metallurgical Society Bylaws, Article VI, Sections 1 and 2, and not inconsistent with the Constitution and Bylaws of the AIME; to hold meetings for the discussion of extractive metallurgy; to stimulate the writing, presentation, and discussion of papers on extractive metallurgy; to reject or accept such papers for presentation before meetings of the Division, and to make recommendations on publication thereof.

Provision for Long-Range Planning Committee:

a. Amend Article XI, Section 1, by adding *Long Range Planning*.
b. Add a new Section 9 to Article IX to read:

The Long-Range Planning Committee shall consist of a chairman, who is Chairman-Elect of the Division, and the following members: the most recent living Division past chairman; and the

past chairman, the current chairman and the vice chairman of the Division's Papers and Programs Committee. The Chairman of EMD shall serve as an ex-officio member. It shall be the duty of the committee to recommend to the Executive Committee of EMD the organizational and structural changes and other facets affecting the growth of the Division when deemed necessary, or desirable. It shall advise the Executive Committee of practices in other Divisions that might be employed advantageously by EMD. It shall recommend to the Executive Committee of EMD the principal program, theme, or topic for the Annual Meeting two years hence. It also shall recommend tentative program topics for the next following succeeding two years.

c. Change the numbering of present Article IX, Section 9, to Section 10.

Election of Division Officers

Revision recommended of Article VIII, Section 3, to read:

Any ten members of the Division may submit additional nominations for one or more elective offices to the Chairman and the Secretary of the Division not later than August 15, and the name of the nominee, if his acceptance in writing is obtained, shall be published in the next issue of the JOURNAL OF METALS, and shall be included in the official ballot.

Article VIII, Section 4, revised to read as follows:

The voting shall be by letter ballot, except that when only one candidate has been nominated for each elective position by August 15 following publication of the Nominating Committee report in the July issue of the JOURNAL OF METALS (or thirty days after publication in a subsequent issue), no letter ballot shall be sent to the membership and the candidates shall be declared elected at a subsequent meeting of the Executive Committee of the Division.

Approval of Bylaws

Article X, Section 2, reads as follows:

Proposed amendments shall be considered by the Executive Committee and announced to the members through the columns of the JOURNAL OF METALS together with any comments or amendments made by the Executive Committee thereon. They shall be voted on at the next Annual Meeting of the Division or by letter ballot as may be directed by the Executive Committee.

Accordingly, the above bylaw amendments are subject to approval at the Division's Annual Business Meeting in New York on Wednesday, February 21, 1962.

Officers and Committee Members

EXTRACTIVE METALLURGY DIVISION

R. C. Cole, Chairman
R. Schuhmann, Jr., Past-Chairman
W. R. Opie, Chairman-Elect
M. A. Steinberg, Vice Chairman
Paul Queneau, Vice Chairman
R. J. Stevens, Vice Chairman
T. D. Jones, Treasurer
R. W. Shearman, Secretary

Executive Committee: W. A. Krivsky, '63, C. L. McCabe, '62, T. E. Moore, '64, H. W. St. Clair, '64, J. D. Sullivan, '62, G. H. Turner, '63.

Standing Committees

Extractive Metallurgy Division Lecture: B. W. Gonser, Chairman, J. B. Clemmer, T. B. King.
Extractive Metallurgy Division Award: A. W. Schlechten, Chairman, B. W. Gonser, R. L. Hennebach, W. R. Opie, H. W. St. Clair.
Long-Range Planning: W. R. Opie, Chairman, R. C. Cole, R. Schuhmann, Jr., M. A. Steinberg, G. H. Turner.
Membership: R. J. Stevens, Chairman, W. H. Magruder, Vice Chairman. R. F. Doelling, R. C. Enochs, R. E. Halfacre, J. H. Halley, Ralph Hennebach, C. M. Holmstrom, A. H. Kunkel, Jr., J. N. Lambe, J. B. Rosenbaum, P. F. Stryker, R. W. Wilks.
Nominating: A. E. Lee, Jr., Chairman, R. C. Cole, H. H. Kellogg, W. R. Opie, J. D. Sullivan.
Papers and Programs: W. R. Opie, Chairman, G. H. Turner, Vice-Chairman, J. E. Dore, H. A. Durney, Jr., R. A. Gustison, R. L. Hennebach, F. L. Holderreed, T. L. Hurst, T. R. Ingraham, J. A. Leary, R. S. Long, W. F. Rappold, F. M. Stephens, Jr.
Publications: C. L. McCabe, Chairman, R. E. Lund, Vice Chairman, Paul Queneau, A. S. Russell, W. A. Krivsky, M. E. Wadsworth, D. H. Baker, Jr., R. A. Lewis, R. E. Shinkoskey, W. W. Stephens, G. Derge, Ex-Officio.

Technical Committees

Copper, Nickel, and Precious Metals: F. L. Holderreed, Chairman, J. B. Clemmer, Past Chairman, W. H. Hoard, Vice Chairman, F. Archibald, R. C. Hills, E. F. Rosenblatt, A. E. Beck, Jr., John Leckie, J. J. Bean, R. E. Shinkoskey.
Electrolytic Processes: H. A. Durney, Jr., Chairman, F. H. Buttner, Past Chairman, W. A. Brytczuk, Vice Chairman, R. A. Lewis, H. R. Hanley, T. A. Henrie, J. H. Jacobs, P. T. Stroup, Walter Schmittroth, W. D. Southard, F. S. Weimer.
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Hydrometallurgy: F. M. Stephens, Jr., Chairman, K. C. Vincent, Past Chairman, W. C. Hazen, Vice Chairman, A. M. Wilson, W. D. Howes, S. F. Ravitz, A. J. Thompson, M. E. Wadsworth, D. E. Warnes.
Lead, Zinc, & Tin: R. L. Hennebach Chairman, G. Bjorling, Past Chairman, C. H. Cotterill, Vice Chairman, G. A. Allison, D. F. Ingvoldstad, K. D. Loughridge, H. R. Bianco, H. I. Elvander, M. L. Hughen, J. A. Marvin, Jr., R. B. Paul, G. T. Wever.
Light Metals: J. E. Dore, Chairman, R. A. Lewis, Past Chairman, Felix Litton, Vice Chairman, S. R. Milliken, J. J. Wegner, D. S. Arnold, C. A. Licht, C. W. Schwenzfeier, D. M. Checkley, R. M. Kibby, D. L. LaVelle, J. F. Smith.
Nuclear Fuel Reprocessing: J. A. Leary, Chairman, W. D. Wilkinson, Past Chairman, R. E. Grace, Vice Chairman, G. E. Brand, A. E. Martin, J. W. Ullmann, J. H. Frye, Jr., G. W. Wunder.
Physical Chemistry of Extractive Metallurgy: T. R. Ingraham, Chairman, J. H. Downing, Past Chairman, O. W. Moles, Vice Chairman, R. P. Abendroth, D. W. Morgan, G. R. St. Pierre, J. M. Cigan, T. A. Henrie, H. H. Kellogg, H. G. Poole.
Pyrometallurgy: T. L. Hurst, Chairman, C. H. Aall, Past Chairman, C. J. Lewis, Vice Chairman, R. C. Brinton, M. T. Reikie, R. E. Vener, J. C. Carlile, J. H. Reimers, L. C. Banning, G. C. Beals.
Refractories: W. F. Rappold, Chairman, H. R. Hanley, Past Chairman, N. R. Alston, Vice Chairman, R. J. Stevens, R. G. Bowman, L. E. Cupp, L. T. Eck, C. D. Henderson.
Uranium, Rare Earths & Minor Metals: R. S. Long, Chairman, M. F. McCarty, Past Chairman, P. R. Kruesi, Vice Chairman, R. G. Beverly, H. G. Petrow, C. J. Lewis, J. B. Rosenbaum, R. S. Olson, W. P. Roe, E. H. Snyder, Jr.

Special Committees

Study of EMD Textbook Publication: T. B. King, Chairman, Gerhard Derge, H. H. Kellogg, A. W. Schlechten, Reinhardt Schuhmann, Jr.
1962 Symposium on Extractive Metallurgy of Aluminum: R. A. Lewis, Chairman.
1963 Symposium on Unit Processes in Hydrometallurgy: M. E. Wadsworth, Exec. Chairman, F. T. Davis, Co-Chairman.

Committee Officers and Members

THE METALLURGICAL SOCIETY OF AIME

Robert Lansing Hardy Gold Medal: R. L. Smith, Chairman, Norman Weiss, MBD Representative, H. W. St. Clair, Michael Tenenbaum.
Membership: J. H. Keeler, Chairman, Alan Lawley, C. A. Lovgren, R. J. Stevens.

(Continued on page 450)

STUDENT NEWS

DUBRAWKA WINS PRIZE PAPER CONTEST

Edward G. Dubrawka, winner of The Metallurgical Society's Student Prize Paper Contest in the Undergraduate Division, is currently serving as a second lieutenant with the US Army's Corps of Engineers at Fort Belvoir, Va.

He received a B.S. in Metallurgical Engineering from Carnegie Institute of Technology, and was employed as a metallurgist in the physical testing section of Allegheny Ludlum Steel Corp.'s Quality Control Laboratory before beginning his army service.

Mr. Dubrawka's paper, **Gas Flow in an Oxygen Converter,** was entered by the Pittsburgh section, AIME. The winners in the contest were announced at the Welcoming Luncheon of the AIME Annual Meeting in St. Louis.

A summary of the prizewinning paper appears on this page.

Gas Flow In An Oxygen Converter

(Summary of the Dubrawka Paper)

The purpose of this investigation was to study some of the variables in a system which is metallurgically important today—a gas stream impinging on a liquid bath surface. The model was designed to resemble some of the hydrodynamic aspects of an oxygen converter.

The model was sufficiently flexible so that a single variable could be isolated and studied. Nozzle height above the bath, bath diameter, bath depth, bubbling, stirring, and slag layer effects were the variables studied in the system. Nozzle design was somewhat slighted in this investigation due to the fact that there is sufficient engineering knowledge about nozzles and satisfactory nozzles can readily be designed. The study of stirring, bubbling, and slag layers was not extensive in this research; therefore, more experimentation needs to be conducted using the model.

Procedure

The apparatus comprised a nozzle-lance arrangement, a needle valve, a pressure tap with manometer, and a regulator valve, all connected by ¼ in. diam copper tubing. The nozzle-lance arrangement consisted of a stainless steel tube for a lance and a machined aluminum alloy convergent-divergent nozzle. Both parts were treaded and joined by a treaded ring connector.

The nozzle exit angle of divergence was 7°, which allowed minimum exit friction loss. The convergence ahead of the nozzle throat served to minimize eddy currents near the throat area.

The Froude Number (N_{Fr}) of the model and an operating oxygen converter were to be similar. From Jones and Laughlin data, 5000 cfm of oxygen was deduced as an average flow rate and 70 in. was given as a usual height for the nozzle about the bath (nozzle throat diam, 1 in.). Assuming the height of the nozzle above the bath as a satisfactory dimensional parameter, the Froude Number was calculated for the operating converter. A nozzle height above the bath of 3 in. was approximated for the model. Using 3 in. for the Froude dimensional parameter and the calculated N_{Fr}, a velocity was calculated for the model. This was the gas stream velocity. Knowing the velocity, and also the practical CO_2 gas flow rates available for use, a convenient nozzle throat diameter was calculated to be ⅛ in.

A CO_2 gas regulator valve in conjunction with a needle valve was the means employed for controlling the gas flow to the nozzle. The needle valve permitted accurate control of the gas flow rate, and it also ensured that the gas flow rate remained constant from trial to trial. A float-type flowmeter was used to check the flow rate from the nozzle. The desired flow rate was obtained by adjusting the needle valve and observing the flowmeter readings. The proper needle valve setting was not tampered with, and the gas regulator valve was used on the on-off gas control. The pressure tap in the line was connected to a water manometer which was also used as a check on the flow rate.

A chemical titration was the means employed to determine the amounts of CO_2 gas absorbed into the NaOH solution bath. The following reaction was assumed to be dominant in the bath:

$$2NaOH + CO_2 \rightarrow Na_2CO_3 + H_2O$$

The original molarity of the NaOH solution was known, and after CO_2 gas had been blown onto the bath, a sample of the bath was titrated to determine final molarity. The difference between the initial and final amounts of NaOH in the bath was the amount of NaOH consumed in the above reaction. Simple mole relationships gave the amount of CO_2 absorbed by the bath. The accuracy of the determination of CO_2 gas absorbed by the bath depends mainly on the titration.

Discussion

The direct results of this study dealt with the experimentation on the model itself, but the primary purpose of this investigation was to correlate model results with a large scale operation of commercial interest, if possible. To do this, the data would have been put in the form of parameters which were common to both the model and the commercial operation in mind. Since the oxygen converter was the process the model was likened to, the parameters were not difficult to obtain. The Reynolds Number or the Froude Number were possible choices for the correlation desired. However, to have employed these numbers would have required a study of the CO_2 gas flow rate in the system and its influence on the gas absorption. Velocity of the gas stream is a term in both the Reynolds and Froude Numbers. The length parameter that might possibly have been used in either the Reynolds or Froude Number was one of the three dimensions studied in the system—bath depth, bath diameter, or nozzle height above the bath.

From the results, two important ratios could have been calculated: bath depth-to-bath diameter and nozzle throat diameter-to-bath di-

ameter, which were both cases for maximum or optimum CO_2 gas absorption. The values would be design features for possible use in an oxygen converter. However, both of the ratios would have been influenced in some way by the kinetic energy of the gas stream. As discussed previously, flow patterns in the bath were related to the optimum bath depth, and surface turbulence was related to bath diameter and nozzle height above the bath. The effect of gas velocity on surface turbulence and stirring was not studied. The two ratios mentioned would only be valid for the given conditions in the system—especially gas stream velocity. Gas stream velocity was not varied in any part of the experimentation.

The nozzle height above the bath, bath depth, and bath diameter were variables that were relatively easy to isolate, study, and compare with an oxygen converter. The effects of gas evolution in the bath and slag layers on the liquid bath were difficult to represent in realistic manner, but the results obtained were similar to what would be expected in an oxygen converter. Gas evolution in steelmaking causes stirring and surface turbulence and effectively increases the surface area of the bath exposed to the atmosphere above the bath. Similar results were observed in the model whereby CO_2 gas absorption increased due to nitrogen bubbling in the bath. The combination of nitrogen gas bubbling and a soap bubble *slag* resulted in very high gas absorption in the bath. It was interesting to note that increased gas absorption amounted to 40 pct compared to a trial with no bubbling, and the increased gas absorption employing the soap bubble *slag* layer and nitrogen bubbling combined was 50 pct more than in a trial using no slag or bubbling.

Conclusions

As a result of this study, the following conclusions can be drawn:

1) For a given flow rate and nozzle throat diameter, an optimum nozzle height above the bath existed for maximum CO_2 gas absorption into the bath;

2) Gas absorption into the bath rapidly increased with increasing bath diameter up to 12 in., but further increasing the bath diameter resulted in only slightly increased CO_2 gas absorption;

3) The CO_2 gas absorption in the bath increased as the bath depth increased to 4 in., but absorption did not increase any further as bath depth increased from 4 to 6 in.;

4) Definite stirring currents existed in the bath volume and on the bath surface;

5) The ratio of bath depth to bath diameter where bath stirring was fully developed was 0.90 for the given experimental conditions; and

6) Bubbling nitrogen gas through the bath increased CO_2 gas absorption in the bath by 40 pct, and bubbling nitrogen gas in conjunction with a soap bubble *slag* layer increased CO_2 gas consumption in the bath by 50 pct compared to a similar trial with no slag layer or nitrogen bubbling.

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H. A. Hashimoto: Gas Flow in Top Blown Oxygen Converter, *Tetsu to Hagane*, vol. 44, 1958, pp. 222-223.

NEW STUDENT MEMBERS

May

Aachen University (West Germany)
Lakshmanan, Ramaswamy

University of Arizona
Crawford, Leslie P.

Case Institute of Technology
Blazek, William S.
Stuhrke, William F.

Colorado School of Mines
Huddleston, James B.
Meyer, Jon P.
Zohn, Gary O.

Columbia University
Dubroff, William

Cornell University
Christ, Bruce W.
Kaiser, Harold F., Jr.

Drexel Institute of Technology
Potter, LeRoy C.

Illinois Institute of Technology
Bates, James T.

Kings College (U. K.)
Ayer, Robert
Black, Hugh
Blankenburg, Gunars
Bowman, David W.
Preston, Raymond A.

Lafayette College
Grabarits, John J.
Hulsizer, William R.

Leeds University (U. K.)
Dower, Robert J.

Lehigh University
Goldwaite, Val. R.

Universite de Liege (Belgium)
Fels, Fernand J.

Massachusetts Institute of Technology
Hayden, Howard W., Jr.

Michigan State University
Vaughen, Marian R.

Michigan College of Min. & Technology
Butrymowicz, Thomas F.

University of Michigan
Allen, Robert G.
Bleicher, Frederick, Jr.,
Dasen, Janice M.
Didier, Jay A.
Gassenheimer, Earl H.
Hernandez, Luis R.
Kaplan, Robert
Kumble, Raghvir G.
Madden, Gerald I.
Rodriguez, Faustino R.
Schroeder, David L.
Sosa, Carlos R.
Tait, Ronald D.
Tanke, Richard L.
Tokar, Michael
Westin, Robert A.
Ziegelman, Rosalie

Missouri School of Mines
Bingaman, Terry B.
Romani, Jorge
Twidwell, Larry G.

Montana School of Mines
Stephens, Patricia A.

Univ. of New South Wales (Australia)
Jostons, Adam

New York University
Hoffman, Robert A.

Ohio State University
Worth, Gerald W.

University of Pennsylvania
Dash, Domanath
Giantz, Michael H.

Pennsylvania State University
Fleck, James N.
Graham, Arthur H.
Michlin, David S.
Parry, Richard H.
Sowers, Carl W.

University of Pittsburgh
Ecer, Gunes M.
Klein, Harvey I.
Miller, John C.
Pittinato, Gabriel F.
Skarja, John A.
Stone, Daniel H.
Wechuck, Leon J.

Purdue University
Grot, Robert E.
Trubey, David R.

Stanford University
Donnelly, William D.
Hollywood, Leigh P.

University of Syracuse
Mukerjee, Tapan

Texas College of Arts & Industries
Schneider, Norbert R.

University of Utah
Zaia, Natvarsinh M.

Virginia Polytechnic Institute
Ellis, Robert W., Jr.
Greene, Alexander B.
Jamison, Larry D.

Washington University
Bloom, Bernard

University of Washington
Hopper, Robert W.

Washington State University
Secor, Ronald A.

Wayne State University
Barkovich, Karl L.
Chaplin, James
Crenshaw, Herbert C.
Doehring, Richard C.
Dunn, Robert C.
Padden, James B.
Schaefer, Jack E.
Tafel, Ralph A.
Ward, James R.

University of Wisconsin
Hansen, James D.
Jewett, Robert P.
Lewis, Lawrence I.
Noreen, Richard A.
Sellers, Robert E., Jr.
Wilhelm, Glenn C.

June

Case Institute of Technology
Burnett, Alan J.
Harris, Don E.
Harsch, Dennis C.
Whiteman, Michael B.

Colorado School of Mines
Mayadas, Ashok

Illinois Institute of Technology
Lewis, Ted E.

Kings College (England)
Wraith, Albert E.

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Committee Officers

(Continued from page 447)

Committee on the Metallurgical Profession: W. R. Hibbard, Jr., Chairman, R. C. Cole, J. J. Harwood, T. B. King, C. L. McCabe, E. R. Morgan, B. R. Queneau, R. J. Raudebaugh, G. A. Roberts, A. W. Schlechten, Morris Tanenbaum, Merritt Williamson.

Engineering Management: W. R. Hibbard, Chairman, D. J. Blickwede, J. H. Jackson, M. W. Lightner, J. H. Scaff, M. A. Steinberg.

Finance: A. W. Thornton, Chairman, H. B. Emerick, T. D. Jones, A. R. Lytle.

Nominating: A. E. Lee, Jr., Chairman, C. S. Barrett, B. W. Gonser, N. J. Grant, T. D. Hess, W. R. Hibbard, Jr., B. R Queneau, T. A. Read, H. W. St. Clair.

Programs: C. R. Taylor, Chairman, F. W. Luerssen, W. R. Opie, R. L. Smith, M. A. Steinberg, David Swan.

Publications: C. L. McCabe, Chairman, Ex-Officio: H. H. Kellogg, K. L. Fetters, H. L. Bishop, W. A. Krivsky, F. C. Langenberg, R. E. Lund, W. O. Philbrook, L. L. Seigle, R. L. Smith, F. L. Vogel.

Special Committees

Metals Research Publications Fund: A. R. Lytle, Chairman, A. E. Lee, Jr., C. M. Parker, R. J. Raudebaugh.

Fiscal Policy and Future Developments: David Swan, Chairman, H. B. Emerick, T. D. Dones, C. C. Long, A. R. Lytle, O. T. Marzke, J. S. Smart, Jr., A. W. Thornton.

Special Conference Committees

Magnetics Conference: P. A. Albert

New England Regional Conference: C. M. Adams, Jr., Chairman, D. L. Martin, Past-Chairman, R. P. Carreker, Jr., Vice-Chairman, W. P. Matthew, Secretary, R. E. Keith, Treasurer.

Student Members

(Continued from page 449)

University of Kentucky
Fister, Julius C., Jr.
Margolis, William S.
Swanson, Russell E.

Lafayette College
Huston, Ernest L.
Lutz, Walter S.

University of Maryland
Witmer, Dennis A.

University of Massachusetts
Mraz, David J.

Massachusetts Institute of Technology
Bardes, Bruce P.
Cavanaugh, Charles R.

Michigan State University
Korpak, Charles
Young, William B.

Missouri School of Mines
Gago, Oscar G.
Nelson, Kenneth R.
Park, Won Choon
Rana, Mahendra N.
Redline, Richard H.
Steimley, John F.

University of Nevada
Jellett, Morgan J.
York, Charles B.

New York University
Papazian, John M.
Steier, Marvin F.

Northwestern University
Arsenault, Richard J.

University of Notre Dame
MacMillan, Charles A.

Pennsylvania State University
Maute, Kurt W.

Texas Western College
Bradshaw, Charlie
Farraro, John T.
Sipler, Albert B.

University of Toronto
Ohno, Atsumi
Seth, Brij B.

Washington State University
Javorsky, Charles A.

Wayne State University
Behr, Charles D.

University of Wisconsin
Holman, John C.

Student Member Application Contest

The student chapter of The Metallurgical Society at the Colorado School of Mines has been awarded a $100 check as the winner of the 1960 Student Member Application Contest for submitting the largest number of student member applications.

Pennants were awarded to the student chapters that submitted the next highest number of student member applications. They were: University of Texas, Missouri School of Mines, Louisiana State University, Montana School of Mines, and Brooklyn Polytechnic Institute.

Change of Address

▼To be sure that you receive your publications and correspondence promptly, please fill in the form below and send it to **The Metallurgical Society of AIME, 29 W. 39th St., New York 18, N.Y.**

Name _____

Old Mailing Address _____

_____

_____

New Mailing Address _____

_____

_____

Personals Form

▼**Personals:** Please list below your former company and title and your new title and company (or new work) for use in JOURNAL OF METALS. (Copy deadline for personals items is six weeks before date of issue.)

Former Company _____

Former Title _____ Length of Time There _____

New Company _____

New Company Address _____ Date of Change _____

New Title _____

Any recent activity that would be of interest to members:

_____

_____

_____

PROPOSAL FOR AIME MEMBERSHIP

I consider the following person to be qualified for membership and request that a membership kit be mailed to him:

Name of Prospective Member:

_____

Address

_____

_____

_____

Name of AIME Member:

_____

Address

_____

_____

_____

JM

MEMBERSHIP

Proposed for Membership
Metallurgical Society of AIME

Total AIME members on April 30, 1961, was 34,678; in addition 1,977 Student Members were enrolled.

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The Institute desires to extend its privileges to every person to whom it can be of service, but does not desire as members persons who are unqualified. Institute members are urged to review this list as soon as possible and immediately to inform the Secretary's office if names of people are found who are known to be unqualified for AIME membership.

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OTS Translation

(Continued from page 402)

OTS on a subscription basis, by general subject categories.

About 450 abstracts per month on metallurgy, metals, metal products, and nonmetallic minerals are published. A subscription for six months costs $18.00.

OTS recently entered into a new cooperative agreement between the United States and a number of European countries to provide broader Western World distribution of translations of Russian and other Eastern European scientific literature that may be useful. A European Translation Center, sponsored by 12 member countries of the European Productivity Agency, has been established at the Technical University at Delft, Netherlands. It was created to: provide liaison among European countries handling Russian and East European translations; serve as a center for bibliographic information on the availablity of translations; and collect non-commercial translations from countries prepared to contribute them.

In its capacity as the US Government's translation center, OTS is currently assisting the European Translation Center in establishing procedures for bibliographic and other work. OTS and the European Translation Center are exchanging both translations and bibliographic data, and are using uniform methods of classification of all materials. The OTS publication, *Technical Translations*, will be used as the announcement medium for material collected by the Center, which is expected to greatly increase the circulation of the publication in Europe.

These new sources of information are contributing to the increasing volume of new translations being added each month to the OTS collection. One category where increases are especially noted is in translations from Communist China, which is trying to catch up with Russia and the West in applied technology. By continually modifying, modernizing and diversifying its translations services, OTS is increasing its capacity to better serve science and industry by providing more material, in more useable form, at minimum cost.

NECROLOGY

Year Elected	Name	Date of Death
1952	Aldredge, R. F.	Unknown
1919	Alling, H. L.	July 1960
1897	Atwater, R. M., Jr. (Legion of Honor)	Mar. 1961
1927	Austin, Bert C.	Unknown
1956	Bannister, R. Peter	Feb. 11, 1961
1952	Brubaker, W. B.	May 1960
1904	Channing, R. H. (Legion of Honor)	Apr. 1, 1961
1945	Corbin, C. H.	June 1960
1956	Corley, R. O.	Nov. 13, 1959
1931	Dyer, John Paul	Mar. 19, 1961
1957	Farling, H. L.	Sept. 26, 1960
1955	Farmer, Max C.	Dec. 12, 1959
1959	Garnero, Joseph	July 1960
1918	Geisendorfer, H. A.	Sept. 21, 1960
1918	Gester, G. C.	Nov. 24, 1960
1949	Gillison, Geo. T.	Unknown
1933	Gray, Lloyd L.	June 1960
1937	Hobson, W. E.	Unknown
1956	Holloway, Claude L.	Mar. 23, 1961
1954	Janney, John B.	July 15, 1960
1958	Ketcham, Robert T.	Dec. 4, 1960
1916	Li, Kuo C.	Mar. 7, 1961
1947	Retty, J. A.	Mar. 14, 1961
1931	Rice, Arthur J.	Mar. 31, 1961
1913	Rolle, Sidney	Mar. 25, 1961
1900	Selkirk, W. (Legion of Honor)	Feb. 16, 1961
1959	Taylor, Harold E.	Nov. 1960
1920	Tomlinson, C. W.	Apr. 3, 1960
1920	Tregonong, R. A.	Nov. 10, 1960
1943	Thompson, Norman E.	Feb. 18, 1961

Ernest Edgar Thum

Ernest Edgar Thum, 76, director of editorial services of the American Society for Metals, died suddenly April 10, in Coronado Beach, Calif., where he was vacationing with his wife.

Mr. Thum was editor-in-chief of *Metal Progress*, and its first editor when the magazine was established in 1930. He was named editor-in-chief in 1958. Only a month before his death he had been appointed director of editorial services.

Before joining ASM he had been principal associate editor of *The Iron Age*. During his professional career he was also the associate editor of *Metallurgical and Chemical Engineering*, and professor of metallurgy at the University of Cincinnati.

He is survived by his wife, two sons, and two daughters.

Joseph H. Brennan

Joseph H. Brennan, 58, chief metallurgist of Union Carbide Metals Co., and the holder of several patents in chemistry and metallurgy, died April 19 in Niagara Falls, N. Y. He had been in poor health since suffering a heart attack in February, after returning from a trip to Norway.

Closely associated with the ferroalloy industry, he had been employed by affiliates of Union Carbide for 26 years. He was interested in determining more economical methods for producing alloys with a low carbon content, and much of his research was in this direction.

For his contributions to metallurgy, he was awarded the Frank J. Tone Award of AIME's Niagara Frontier Section.

He is survived by his wife and three sons.

Coming Events

June 12, 1961, Pittsburgh Section, NOHC, Annual Golf Party, St. Clair Country Club.

June 14, 1961, Northern Ohio Section, NOHC, Annual Golf Party, Squaw Creek Country Club, Youngstown, Ohio.

June 17, 1961, Cleveland Section, NOHC, Annual Dinner Dance, Lake Shore Hotel, Cleveland.

June 18-23, 1961, AIEE, Summer General Meeting, Cornell University, Ithaca, N. Y.

June 20-24, 1961, Fourth Plansee Seminar on Powder Metallurgy in the Nuclear Age, Reutte/Tyrol, Austria.

June 25-30, 1961, ASTM National Meeting, Chalfonte-Haddon Hall, Atlantic City, N. J.

June 26, 1961, ASTM, 64th Annual Meeting, Chalfonte-Haddon Hall, Atlantic City, N. J.

Aug. 7-9, 1961, Annual Conference on Applications of X-Ray Analysis, Park Lane Hotel, Denver, Colo.

Aug. 30-Sept. 1, 1961, AIME Third Technical Conference on Semiconductors, Ambassador Hotel, Los Angeles.

Aug. 31, 1961, Chicago Section, NOHC, Annual Golf Outing, Gleneagles Country Club.

Sept. 17-20, 1961, Commemoration of the 50th Anniversary of Froth Flotation, Cosmopolitan Hotel and Brown Palace Hotel, Denver, Colo.

Oct. 2, 1961, Chicago Section, NOHC, Fall Technical Dinner Meeting, Phil Smidt's Restaurant, Chicago.

Oct. 5-6, 1961, Southwestern Section, NOHC, Annual Fall Meeting, President Hotel, Kansas City, Mo.

Oct. 17-Nov. 7, 1961, Visit of the Iron & Steel Institute (United Kingdom) to the United States.

Oct. 20, 1961, Eastern Section, NOHC, 15th Annual Technical Conference, Warwick Hotel, Philadelphia.

Oct. 23-26, 1961, Fall Meeting of The Metallurgical Society of AIME, Pick-Fort Shelby Hotel, Detroit.

Nov. 3, 1961, Pittsburgh Section, 16th Off-the-Record Meeting, Penn-Sheraton Hotel, Pittsburgh, Pa.

Nov. 13-16, 1961, Seventh Annual Conference on Magnetism and Magnetic Materials, Hotel Westward Ho, Phoenix, Ariz.

Dec. 4, 1961, Annual Meeting, Arizona Section, AIME, Pioneer Hotel, Tucson, Ariz.

Dec. 6-8, 1961, 19th Electric Furnace Conference, Penn-Sheraton Hotel, Pittsburgh, Pa.

Feb. 18-22, 1962, AIME Annual Meeting, New York, N. Y.

April 26-28, 1962, AIME Pacific Northwest Metals and Minerals Conference, Ben Franklin Hotel, Seattle, Wash.

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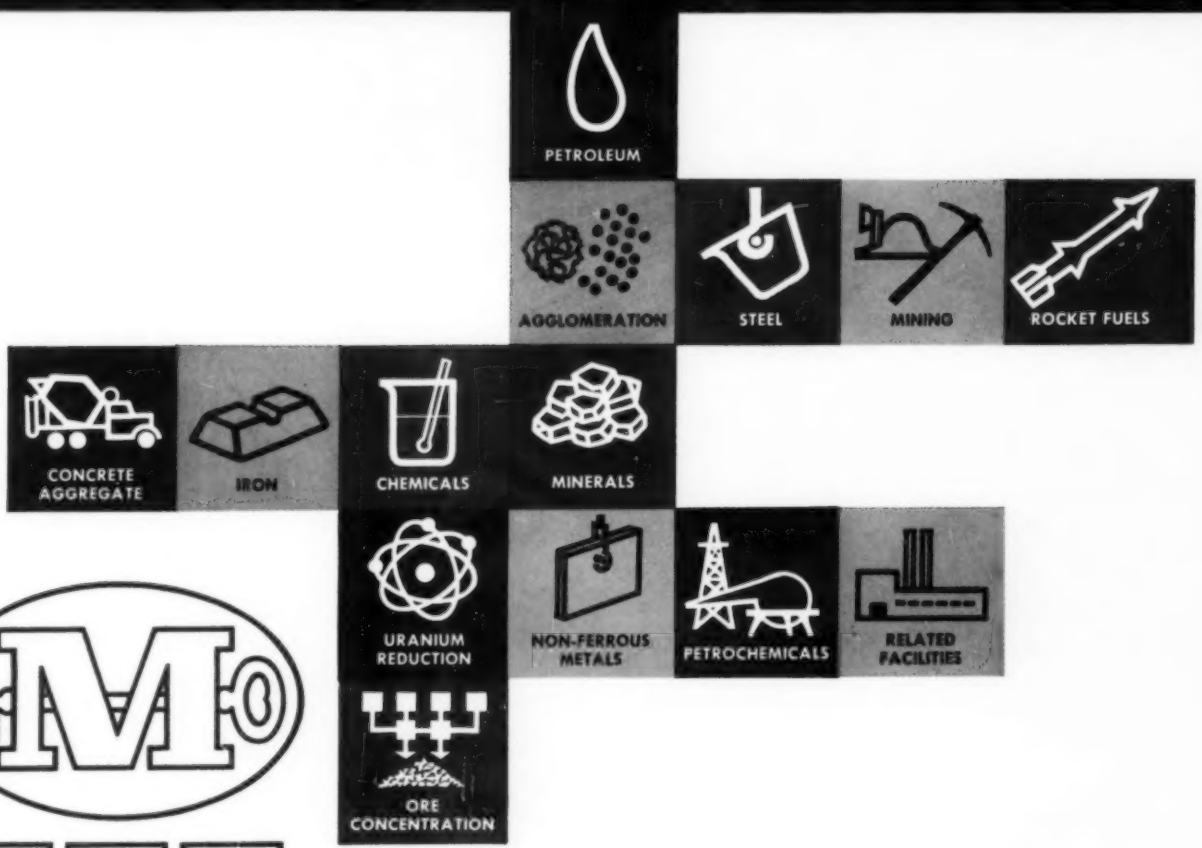

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